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REPORT

OF THE

JOINT SPECIAL COMMITTEE

OF THE

COURT OF COMMON COUNCIL

AND THAT OF

CITY ENGINEER FREDERICK L. FORD

ON THE

EAST SIDE FLOOD PROTECTION

HARTFORD, CONN.

1908-1909

VIEW OF THE CONNECTICUT RIVER IN REPOSE IN THE VICINITY OF HARTFORD BRIDGE.

REPORT

OF THE

JOINT SPECIAL COMMITTEE

OF THE

COURT OF COMMON COUNCIL

ON

EAST SIDE FLOOD PROTECTION

AND THAT OF

CITY ENGINEER FREDERICK L. FORD

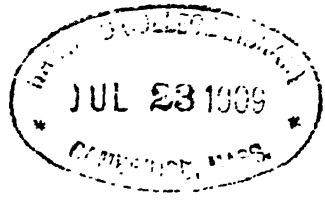
UPON

(1) A General Plan for the Abatement of the Nuisance Caused by Freshets in the Connecticut River
(2) The Improvement of Sewerage Facilities in the Colt Meadow District
(3) The Future Disposal of Sewage from the Franklin Avenue Sewerage District

Submitted to the Court of Common Council on October 12, 1908, February 23, and March 8, 1909

HARTFORD, CONN.:
THE CASE, LOCKWOOD & BRAINARD CO.
1909

Eng 1019.09.11



HARTFORD, CONN., October 12, 1908.

To the Honorable Court of Common Council:

SIRS: — We beg to submit herewith the report of City Engineer Frederick L. Ford, upon a general plan for the abatement of the flooding nuisances caused by freshets in the Connecticut River.

This plan provides

First: For an intercepting sewer to start at the foot of Keney Lane or Potter Street where it would discharge into the Connecticut River, thence to run westerly to Commerce Street; thence northerly through Commerce Street and Connecticut Boulevard to Kilbourn Street; thence westerly to Charles Street; thence northerly to Talcott Street; thence westerly to Front Street; thence northerly to Morgan Street; thence westerly to Market Street; thence northerly to Pleasant Street; thence westerly to Village Street or Windsor Street; thence northerly in Village Street or Windsor Street to Avon Street. This sewer would be laid out to discharge by gravity until water in the Connecticut River rose to about elevation fifteen, eighteen being the height of the lowest cellar upon the route laid out for the interceptor. If the Connecticut River continued to rise, the gates at the outlet would be closed and pumps of capacity sufficient to handle all sewage and surface water from the area within the dyked district would be started and operated continuously until the water in the Connecticut River receded to elevation fifteen. This intercepting sewer would have to be of varying sizes from about seven feet in diameter at the outlet, to perhaps four feet at the northerly end. The grade would be about one foot in each one thousand feet; the depth sufficient

for ordinary cellars, and considerably deeper than the present sewers to be replaced by the proposed interceptor.

Before the size or grade of this sewer can be exactly determined, it will be necessary to dig test pits at two or three hundred foot intervals over its entire course. These excavations will not only show the nature of the soil to be encountered in the prosecution of the work, but will also give a very fair idea of the amount of ground water liable to infiltrate into the sewer, and indicate the degree of imperviousness which should be attained in the construction of the sewer and the filling of the trench.

In the former reports of engineers upon this same problem, there seems to have been a general idea, that, as much of this land has been made by filling with various kinds of material, extending over a long period, there is a possibility that porous layers will be found at certain depths, and much underground water encountered. Some of the engineers recommended very strongly that borings should be made to determine this element of uncertainty, but we cannot find that this work was ever carried out. It should certainly be done now, because the nature of the soil and the amount of ground water to be handled will necessarily have a great influence upon the cost of the undertaking, as well as upon the sizes of the sewers and the materials used in their construction. The test pits will be dug at right angles to the streets and long enough to show the exact location of the underground structures of other corporations, so as to determine whether it will be necessary to temporarily remove any of them during the construction of the sewer. Up to this time we have made no attempt to have this work done until the general scheme was outlined, but we have now requested the City Engineer to proceed with this work in order to get a closer approximation of the cost of the entire project.

We understand from the City Engineer that at the time Mr. Edwin D. Graves, chief engineer of the Connecticut River Bridge and Highway District Commission, was planning

the Hartford Bridge, the question of the construction of a river front interceptor, to abate the nuisance caused by the discharge of crude sewage into the Connecticut River from the eleven separate sewers between Park River and Riverside Park, was thoroughly discussed by the two engineers at that time, and a plan of the location of such a sewer was made by Mr. Graves.

The route then favored by both engineers, from Kilbourn Street northerly, provided for a location through the entire length of Charles Street, under Morgan Street and northerly through the new freight yard about on the line of Charles Street, to the northeast intercepting sewer which enters the Connecticut River between the Hartford Bridge and the old pumping station of the Hartford Water Works.

Mr. Ford has also informed the committee that the Bridge Commission in its negotiations with the N. Y., N. H. & H. R. R. Co., provided for a right-of-way for the construction of such a sewer through the new freight yard north of Morgan Street.

The location now proposed by the City Engineer, for that part of the interceptor north of Talcott Street, has been selected for the following reasons: First, because this interceptor was not built before the completion of the bridge commission's great work, and hence cannot now be carried out without increased difficulty and much additional expense. The extra cutting through Morgan Street and the new freight yard at their present grade, would make an appreciable difference in the cost of this particular section, and work around the network of freight tracks would be more or less of a hazardous undertaking. Secondly and principally, because the local sewers, especially those in Talcott, Front, Market, Pleasant and Windsor Streets, are old, entirely too shallow and inadequate, and in such a defective condition that all should be rebuilt at an early date. The new interceptor through these streets would be larger and deeper, and provide this congested district with adequate sewerage facilities so much needed at the present time.

By the City Engineer's modified plan, new local sewers discharging westerly into the new interceptor instead of easterly into the northeast trunk sewer, would be required in Pleasant Street, between Market Street and the new freight yard; and in North Street, Pequot Street and Avon Street, but all of these would be small, short, and comparatively inexpensive.

It is proposed to locate the principal pumping station in the vicinity of the corner of Commerce Street and Potter Street, near the junction of the Park River Valley, and the proposed Connecticut River Front intercepting sewers. This site is selected for the double purpose of handling the sewage and surface water from the river front interceptor, while the outlet gates are closed during freshets in the Connecticut River, and for lifting the sewage only, from both interceptors when the Connecticut River is below elevation fifteen, and discharging it into a higher level sewer to later be constructed as an extension of the river front interceptor, either to a new outlet, or possibly to filter beds further down the river.

Even if the Connecticut River Front interceptor were to be extended at this time, south of the outlet of Park River, say to opposite the easterly end of Charter Oak Avenue, or even below this point, it would be necessary to have a pumping station near the corner of Commerce and Potter streets to handle the dry weather discharge of the Park River Valley interceptor. The storm water overflow through Keney Lane or Potter Street is also necessary in either case, because the cost of carrying the large river front interceptor below this point seems to be prohibitory.

After the Connecticut River Front interceptor is completed, if the combined discharge from the two interceptors near Keney Lane prove to be an unbearable nuisance, the river front interceptor can be continued below Park River. The reason it is not included in the present plan, is one of expense only. It is also planned to construct a small pumping station, possibly to work automatically, near the corner of

North Front Street and Avon Street, to lift the sewage from the northeast sewer into the new local sewer planned for Avon Street and discharging into the northerly end of the river front sewer at Village Street or Windsor Street. During severe storms this small station would become overloaded and the surface water, slightly polluted, would pass out through the northeast interceptor into the Connecticut River.

On account of the low grade and large size (60 inches) of this interceptor, near its outlet, it appears to be absolutely impracticable to attempt to carry its entire discharge through the new river front interceptor.

The construction of the sewers as advocated herein, will completely abate the flooding nuisance between State Street and Avon Street, and this seems to be a pressing need.

The problem between State Street and Park River, however, will not be completely solved by the construction of the Connecticut River Front interceptor, because most of the streets in this district east of Front Street are below freshet level, and surface flooding will continue.

The construction of the Connecticut River Front interceptor should, therefore, be followed by the raising of Commerce Street between State Street and Park River, and possibly Potter Street between Commerce Street and Front Street, and a small section of Front Street and Arch Street near their intersection. This would completely dyke the entire area north of Park River and west of Commerce Street, Connecticut Boulevard, and the Valley Railroad embankment north of Morgan Street.

There still would be an unprotected area east of Commerce Street, between Park River and State Street, but several private properties within this district have already been raised above freshet level. A considerable portion of the area between Keney Lane and State Street is now used for wholesale purposes, and the owners of these properties, for their own good, will gradually raise them. There is, however, a small residential section between Keney Lane and

Park River, which would be outside of the protected area. This small district could be raised above freshet level if it continued to be used for residential purposes, but the committee is of the opinion that as the river front wharfage is becoming more and more valuable each year, this small area will soon change from a residential into a business district.

There is still another section of the city where flooding occurs from freshets in the Connecticut River, but on account of its undeveloped character, the freshets cause very little damage or inconvenience at present. As the district develops, the trouble will naturally increase. We refer to the area north of Suffield Street and adjacent to Windsor Street and Windsor Avenue. Windsor Street between Suffield Street and Sanford Street is considerably below freshet level. Last year the grade of Windsor Street between Sanford Street and Windsor Avenue was raised above the danger line. A short section of Windsor Avenue in the vicinity of Fishfry Street is also below freshet level, and is sometimes submerged. By raising the low places in Windsor Street and Windsor Avenue, above referred to, these two streets would then serve as a dyke for the entire area west of them, and prevent surface flooding. This work can be carried out at the present time while the adjacent property is in an undeveloped condition, much more advantageously than in later years.

It is almost impossible to forecast the development of property in this vicinity. At the present time, manufacturing companies are building new plants on Windsor Street, and it looks as though the easterly side of this street would be largely, if not wholly, devoted to such purposes. Very few, if any, buildings of this character would have basements subject to danger from flooding. If private residences should be erected upon either street where the land is below freshet level, the owners should be cautioned about safe cellar depths. The probabilities are that in any event, very few of the cellars would be below freshet level, and these could be protected by back water valves.

The City Engineer has spent a large amount of time and labor in determining the probable cost of raising the entire area above freshet level, for it seemed to the committee from the start that this would be the ideal solution of the river front problem, if it could be successfully carried out at any reasonable expense. In order to fully carry out such a scheme, it would be necessary to have the hearty co-operation of every property owner.

If the streets alone were raised by the city with the idea that eventually every owner would raise his property to the new grade, the city would be liable for damages for changing the grades of the highways unless every property owner signed a waiver of his claim for damages. If this were not done, and actual damages were paid for such changes, the city could assess a part, or perhaps the whole amount of damages awarded for such changes as benefits upon the abutting property.

In the earlier investigations the committee of 1866, consisting of N. H. Morgan, Frank W. Cheney, and Jonathan B. Bunce, strongly recommended the raising of the entire area. In 1867 General William B. Franklin also favored the plan.

Obviously one of the first considerations, if the raising plan were adopted, would be a decision as to the height of the new grade to be safely above freshet level. Upon this question there was quite a difference of opinion among the earlier investigators, as there undoubtedly would be at the present time. General Ellis favored 33.4 for the height of the proposed dyke, the same as the top of Colt's dyke, and two feet above the 1854 freshet (31.4). The 1866 committee, Engineer James Laurie, and General William B. Franklin, favored 34.4, three feet above high water mark of 1854, for the crest of the proposed dyke. In 1896 the counsel committee of Mayor Miles B. Preston recommended a height of 32.4, or one foot above the 1854 freshet. Having in mind the fact that the grade of the new freight yard north of Morgan Street, as well as that of the intersection of Front and

State streets, is about 30.5, approximately ten inches below the 1854 freshet, the City Engineer has estimated the cost of raising the entire flooded area to this grade, and also to elevation 32.0, so that by interpolation, the approximate cost of raising the district to any other grade near these elevations can easily be determined. In these estimates he has figured on removing and replacing the curbing and sidewalks in the streets, the filling in of the highways, yards, and cellars, the raising of all buildings, and the repaving of the streets with macadam and granite.

These estimates are as follows:

FOR ELEVATION 30.5 (10 INCHES BELOW THE 1854 FRESHET).

DISTRICT.	Assessed valuation of property.	Cost if Streets are paved with Macadam.	Granite.
Park River to State St.,	$482,200	$223,641	$245,327
State St. to Morgan St.,	614,560	225,261	241,135
Morgan St. to Railroad,	747,400	193,932	216,447
Total,	$1,844,160	$642,834	$702,909

FOR ELEVATION 32.0.

Park River to State St.,	$482,200	$260,167	$282,570
State St. to Morgan St.,	614,560	253,149	269,601
Morgan St. to Railroad,	747,400	287,144	311,563
Total,	$1,844,160	$800,460	$863,734

FOR ELEVATION 33.5 BY INTERPOLATION.

	$1,844,160	$958,036	$1,024,559

FOR ELEVATION 34.5 BY INTERPOLATION.

	$1,844,160	$1,063,169	$1,131,775

In the sixties, Engineer James Laurie estimated the cost of raising the entire area to elevation 32.4 as follows: District south of Morgan St. and above Commerce St.,

425,000 cubic yards; district north of Morgan St. and above Front St., 700,000 cubic yards; total, 1,125,000 cubic yards at 40 cents, $450,000. The above estimate did not provide for raising the streets in these two districts, which he figures would add $137,500, making $587,500. This estimate of Mr. Laurie's only provides for the cost of filling the entire area, for in his report he says, " in addition, however, to the cost of filling, there would be a large expenditure required for lifting and relaying the paving and flagging, and raising and adapting the present buildings to the new grade."

While the estimated cost of raising the inundated district in the sixties appeared like a vast undertaking, naturally the cost today would be much greater on account of the additional amount of curbing, sidewalks, paving, etc., to be removed, and the greater number of buildings to be raised.

While we have no way of comparing in detail the estimates of James Laurie and City Engineer Ford, because of the great changes in the district during the last half century, we believe the latter's estimates are conservative, as will be seen by an examination of the tables in the detailed report of City Engineer Ford. It is possible that if the work were to be undertaken upon a large scale, the unit prices used in the estimates could be lowered, but unforeseen contingencies would undoubtedly offset the difference.

If the raising scheme were to be adopted, the sewage system for the East Side would naturally be different from that previously outlined in this report. The surface water from the yards and streets could then be discharged directly into the Connecticut River at all times without pumping. If the present sewers were used for such purposes, new sewers would have to be built in all the streets to prevent cellar flooding and to collect the sewage, and an interceptor would be required to carry it to a central pumping station; otherwise the river front would remain as polluted as at present. The only difference in the two sewerage systems would be the excess size and cost of the river front interceptor necessary to carry the large amount of surface water from the district;

and the additional expense of pumping this surface water while the gates were closed during freshets in the Connecticut River, less the cost of providing a double system of sewers back from the river to an elevation above freshet level, in each street where flooding now occurs.

After the large river front interceptor, as first outlined in this report, is completed, and the nuisance from Connecticut River freshets is abated, it is not improbable that the increment in value of property due to the great work of the Bridge Commission and this improvement, will become so marked that the entire character of this section will rapidly change, and large, modern fireproof structures will replace many of the present old, dilapidated buildings. If so, the raising plan could be gradually accomplished, for it has the advantage that it could be carried out in sections from time to time as considered advisable.

In view of the foregoing considerations, the Committee is of the opinion that the city would not favor the raising of the entire area at this time on account of the great expense involved and the difficulty of securing the coöperation of the many property owners, so essential for the successful completion of such a great work.

We believe the river front interceptor and the necessary pumping stations should first be constructed and that they should be of ample size to provide for all surface water within the district.

The City Engineer informs us that in his opinion this work would cost from $300,000 to $350,000, although definite estimates cannot be obtained until test pits have been dug over the entire line.

The Committee is planning to hold public hearings upon this matter in order to test public opinion, upon the different plans of abating this flooding nuisance, for it believes that the general sentiment of the City toward the East Side has changed considerably since the completion of the work of the Connecticut River Bridge and Highway District Commission, and that whatever is done to clean up

the East Side should be in harmony with this great work.

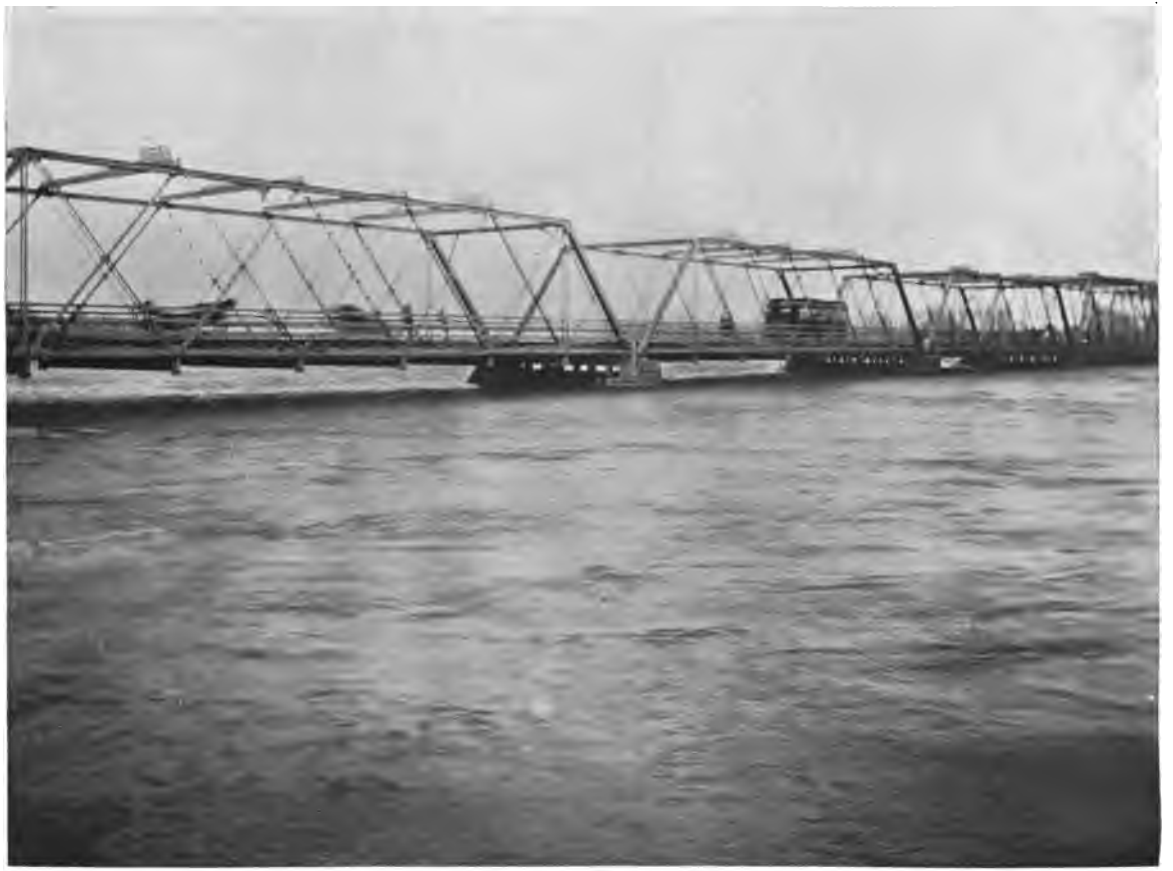
An edition of 2,000 copies of the report of the committee and the detailed report of the City Engineer is being prepared for general distribution, out of the appropriation made for the work of the committee. This is quite essential for a thorough understanding of the report of the City Engineer, as it contains many maps, tables, diagrams, etc., which cannot be reproduced in the council records.

We recommend that all of the reports except maps and diagrams be printed in the Council Journals, because of their permanent value.

Respectfully submitted,

FRANK W. WHITON,
HERMAN P. KOPPLEMANN,
JOHN J. KENEFICK,
ALEXANDER D. MACKINNON,
ELMER A. JACKMAN,
CLAIR S. HUTCHINSON,

Joint Special Committee on East Side Flood Protection.



VIEW OF THE CONNECTICUT RIVER DURING HIGH WATER NEAR THE OLD TEMPORARY STEEL BRIDGE.

Report of City Engineer Frederick L. Ford

UPON A GENERAL PLAN FOR THE ABATEMENT OF THE NUISANCES CAUSED BY FRESHETS IN THE CONNECTICUT RIVER.

HARTFORD, CONN., October 12, 1908.

MR. FRANK W. WHITON,
" HERMAN P. KOPPLEMANN,
" JOHN J. KENEFICK,
" ALEXANDER D. MACKINNON,
" ELMER A. JACKMAN,
" CLAIR S. HUTCHINSON,

Joint Special Committe on East Side Flood Protection.

SIRS: — The subject of this discussion, the protection of the East Side from inundation from freshets in the Connecticut River, is not a new one, as it has been before the citizens of Hartford for the last half century.

At three different times during this period, the discussion has been much more actively considered than during the intervening years.

In the sixties, it was decided to dyke the afflicted section, and plans, specifications and estimates were prepared for carrying out the work. The route was practically agreed upon and the City Council authorized the first expenditure upon this sanitary improvement, but the construction of the Valley Railroad and the organization of the Board of Street Commissioners in the early seventies, postponed the work. During the next twenty-five years, very little progress seems to have been made toward a solution of this perplexing problem. Ex-Mayor Miles B. Preston is entitled to the credit of reviving the discussion in 1896. While each agita-

tion of the East Side Flood Protection Problem has received enthusiastic support, both from the City Government and from interested property owners in the afflicted district, for various reasons nothing has been accomplished directly by the city to relieve the situation as a whole. One surprising feature in connection with a study of this interesting problem is the fact that while freshets, like city governments, have come and gone, they have never been followed, so far as I am aware, by serious epidemics among the residents of the inundated district.

I apprehend that during the last half century there have been times when conditions were ideal for serious trouble, and the fact that it has thus far been averted, should be a matter of general satisfaction.

If epidemics have been prevented in this district, and the death rate has been kept down to nearly normal during this long interval, it has been largely due to the activity and precaution of the residents themselves.

As the history of the efforts to improve the sanitary conditions of this section of the city covers a period of nearly a half century, it seems especially fitting to here incorporate an abstract of the thorough and exhaustive work already accomplished upon this problem. During this period, several eminent engineers, and many of Hartford's most distinguished citizens have reported upon this same problem, and it would be unwise to now adopt any system of relief without carefully weighing the conclusions previously reached by these investigators. Naturally none of the former plans can now be carried out as a whole because of the great changes which a half century of municipal progress has brought about, but it is surprising to find how little difference there really is in the various plans, and equally encouraging to know that the project of today, although more expensive to carry out, does not look as stupendous as it undoubtedly did to Hartford in the early sixties.

FIRST PETITION FOR A DYKE.

While Colonel Colt was building his dyke in the South Meadows the idea was gaining ground that a similar structure should be built by the city north of Park River.

If a private individual could afford to pay the cost of dyking unimproved meadow land, much more, it was argued, could the city afford to pay for protecting its important wholesale and tenement district.

A petition was accordingly presented to the Court of Common Council, signed by Woodruff & Beach, Horace Ensworth, Gridley & Frisbie, and fifty-four other prominent firms and owners of the east side, asking "that your honorable body will direct the *raising of Commerce and Morgan streets in the city, also the north bank of Little River, from the line of Commerce Street to Arch Street,* so as to protect the property within the limits named from the inundations of the Connecticut River."

CITY OBTAINS LEGISLATIVE AUTHORITY TO BUILD DYKES.

The city had no authority at that time to order the construction of such work, so a charter amendment was obtained from the State Legislature (July 7, 1865). This provided "That the Court of Common Council of the City of Hartford shall have the exclusive power to lay out, make and establish, within the limits of said city, any dyke necessary to prevent the water of the Connecticut or Mill River from inundating or overflowing said city, or any part thereof, which shall be considered and treated as a public work of said city."

FIRST REPORT ON DYKE, OCTOBER 23, 1865.

On this authority the Council promptly appointed a committee, consisting of Alderman Woodruff and Councilmen Kellogg, Harbison, Woodruff, and McManus, "to procure plans and specifications and estimates of the proposed dyke on the bank of the Connecticut River."

They reported on October 23, 1865, by submitting a report and map by General Theodore O. Ellis, whom they had engaged for the purpose. The report was published for one week in the four daily papers and the next year two hundred copies were printed with other resolutions of the city government to March 20, 1866 (The Hartford Dyke Reports and other papers, Hartford, Calhoun Printing Company, 1866). On January 28, 1867, one thousand copies were ordered printed, the subject matter requiring by this time a 48-page 6x9 pamphlet entitled "Report of the Committee on the Proposed Hartford Dyke, accompanied by the Reports of the Engineers, January 18, 1867, together with former Reports of the Committees and Engineers. Hartford: Press of Wiley, Waterman and Eaton, 1867."

Both of these reports have long been rare, but the originals are on file at the Halls of Records.

GENERAL ELLIS RECOMMENDS ELEVATION 33.4 FOR TOP OF DYKE.

General Ellis examined all the flood data available and gave a table of the principal heights. He did not investigate the possibilities of floods very much higher than that of *1854*, but assumed that *the top of the dyke should be two feet above that level.*

LOCATION OF DYKE PROPOSED BY GENERAL ELLIS.

He recommended that it run *close to the bank of Little River from the foot of Prospect street to Dutch Point, filling Arch street to the proposed grade; "thence passing along the wharves . . . to the foot of Ferry street; thence along Commerce to Morgan street; thence following the line of the freight track of the Hartford and New Haven Railroad, to near its junction with the main track."*

His arguments against the proposed route wholly in Commerce street was that it left too much valuable property unprotected east of the dyke. As much of this property has since been raised this argument is now less forceful.

GENERAL ELLIS NOT IN FAVOR OF OPENINGS THROUGH DYKE.

Regarding street crossings, he says: "It is proposed to carry all crossings over the embankment at grade, and no provision is made for openings through it for convenience of access to the wharves. *The insecurity of these openings and the danger of their not being properly closed in time of high water, together with the disastrous consequences that might occur from their not being properly secured leads me not to recommend them. They can be so constructed as to be secure if properly taken care of, but the certainty of a solid embankment is far preferable in a permanent structure like this.*"

On the city side the streets would be filled on a 5 per cent. grade to the top of the dyke. On the river side the ramps or slopes down and along the outer slopes of the embankment would connect with the wharves.

He mentions wells inside the dyke lines in which water rises and falls with the river "*seemingly indicating some connection through a quicksand or otherwise with the water in the river.*" The surface of the bank, however, is, he thinks, hard and firm sand deposited by the river, and if at high water the wells should overflow they can be securely filled up . . . . so as to cause no further trouble.

DISPOSAL OF DRAINAGE DURING HIGH WATER IN CONNECTICUT RIVER.

"*The question of disposing of the drainage during high water is perhaps the most important one to be considered in the construction of the dyke,*" as . . . "*we have to provide for all the accumulation of water from sewerage and rainfall within the dyke at such times.*"

He proposed "*to intercept by a surface drain at Front street, between Temple and Arch streets, all the surface water between Main and Front streets.*" This drain would take into Little River all the surface water from a level of

about six feet below the flood of 1854, and a gate at its outlet would not have to be closed unless the water rose above that height.

The sewage between Morgan street and the Little River and all surface drainage not carried off by the Front street drain, above mentioned, is provided for by a sewer in Charles, Commerce, and Potter streets, having its lowest point at the foot of Ferry street.

He did not provide any sewerage plan for the territory north of Morgan street, as "*most of the rainfall appears to be allowed to remain upon the surface of the low ground west of Front street until it soaks into the ground or is evaporated.*"

A sewer was provided to connect the Avon and Pleasant street sewers at one outlet through the embankment at the foot of Pleasant street.

"The amount of damages claimed cannot be estimated with accuracy, as it depends in a great measure upon the feeling among the owners of property affected, in favor of, or against the proposed improvement. If they can be assured that their property inside will be permanently protected, it is to be hoped that a very small compensation for the amount of land actually occupied by the dyke will suffice, and that the owners of wharf property will regard the slightly increased difficulty of access to the river as fully compensated by the security given to their property inside the embankment."

GENERAL ELLIS' ESTIMATE OF COST OF DYKE $224,125.

General Ellis estimated that a dyke 20 feet wide on top, including $66,000 damages, would cost $224,125.00.

As confirming his recommendation, he adds: "The success of Col. Colt's experiment in the improvement upon the South Meadows shows conclusively that a properly constructed embankment will answer the required purpose. The foundation is the same and I am informed the same difficulty

existed regarding wells sunk into the underlying sand, yet no trouble has been experienced from them."

"The drainage of the South Meadows, including the side hill to the west, covering a much larger area than that it is now proposed to protect, can only be disposed of at high water by pumping. No difficulty has yet been experienced on this account. A small engine of 12 H. P., working but part of the time has proved sufficient to free the sewers from water."

On account of the uncertainty of the allowance for damages, this report was referred back to the committee (October 30, 1865), "to report how much money can be raised by voluntary subscriptions from those benefited, which sums so subscribed shall be deducted from the betterments assessed on the parties benefited, and to report what part of the expense shall be assessed on the property benefited."

EIGHTY-TWO PERSONS WERE WILLING TO PAY THEIR SHARE OF COST OF DYKE IN 1865.

The committee reported on December 12th, by submitting a paper with the names of *eighty-two persons or firms* attached *"who are willing to be assessed the whole amount in their proportion for building said dyke."* They also submitted a vote authorizing the expending of more than $10,000 to be voted upon at the next city meeting, December 27, 1865.

FIRST CITY VOTE AUTHORIZING EXPENDITURE OF $10,000 ON DYKE.

A special city meeting was then called to authorize the expense, and on December 27, 1865, by a vote of 972 to 690, permission was given to spend more than $10,000 for this improvement.

FIRST OPPOSITION TO THE CONSTRUCTION OF A DYKE.

Now began, however, a more evident opposition to the project. The term of the Common Council then in power

expired the following spring, and there seemed to be a feeling that the responsibility for this expense, so large for those days, should be placed on the new board. On February 12, 1866, a resolution was passed requesting the old committee to investigate the feasibility of the other routes under consideration and get plans and estimates on them "so that the matter may be fairly presented to the council for action in the premises."

The Mayor, Allyn S. Stillman, delayed his approval of this until the election of the new Council on March 13th. In the meantime, on February 26, 1866, a new joint special committee, consisting of Alderman Woodruff and Councilman Kellogg, Thomas McManus, J. P. Harbison, and S. Woodruff, was appointed "to procure specifications and working plans for building a dyke along the Connecticut and Park Rivers, and advertise for proposals and estimates for building the same, and report the same to this Council as soon as practicable."

DYKE BY COMMERCE STREET ROUTE TO COST $234,675.

The special committee promptly reported on March 20th with a new estimate by General Ellis, showing that the cost by the Commerce street route would be *$10,550* greater than by the route first recommended on account of an increase of *$15,000* in the amount allowed for damages to buildings fronting on Commerce street. They had secured proposals from several contractors, but "the short time allowed did not admit of a very extended notice of the advertisement for proposals for building the dyke," also it "did not allow contractors to make as favorable arrangements as they could wish with the railroad companies for transporting the material.

"Some of the contractors who have looked over the work," they say, "have withheld their proposals under an impression that the work would not be let upon the present bids; others have signified their intention of bidding if the time is extended for receiving proposals.

" The few bids received, however, are such as to satisfy your committee that the work can be done at a cost not to exceed the estimate of General Ellis."

The resolution which made effective the Committee's action was tabled on April 30th, as was a plan for assessing half the cost on the city at large. The ordinance committee was asked to draft an ordinance relating to highways and local improvements " containing suitable provisions for giving notice to all persons interested in any property to be taken for the proposed dyke of the proceedings of the Court of Common Council in that behalf and of the appraisal of damages," and providing also that . . . " the highway committee shall proceed to make assessments of benefits as soon as the dyke is laid out."

On May 28th a remonstrance against further proceedings was tabled. The ordinance committee reported the required ordinance, which was accepted and ordered printed.

June 18th an amendment was referred to them, and later the remonstrance previously tabled, but the committee reported on July 23d against any change.

LAYOUT OF DYKE THROUGH ARCH, FRONT, POTTER, AND COMMERCE STREETS.

The actual resolution laying out the dyke *through Arch, Front, Potter and Commerce streets* was reported by the highway committee on July 9th, but it was tabled, and on August 6, 1866, a committee of review was raised.

NEW COMMITTEE APPOINTED TO INVESTIGATE BEST ROUTE FOR PROPOSED DYKE.

This wholly new committee consisted of N. H. Morgan, Frank W. Cheney, and Jonathan B. Bunce. They were requested to " investigate what is the best route for the proposed dyke; authorized to consult civil engineers as to the comparative merits and expense of the routes already suggested," and " requested to report to this court at the earliest possible date."

They brought in a very thorough report on January 18, 1867, after consulting with General William B. Franklin, then superintendent of Colt's Patent Fire Arms Company, and James Laurie, Esq., civil engineer, who, they remark, was "the gentleman who projected and superintended the construction of the iron bridge of the Hartford and New Haven Railroad at Warehouse Point and of great eminence and skill in his profession."

NEW COMMITTEE RECOMMENDS ELEVATION 34.4 FOR TOP OF DYKE.

The joint committee approved the previous plans as far as they went, but recommended *raising the dyke one foot higher to a grade three feet above the 1854 flood.*

NEW COMMITTEE RECOMMENDS RAISING THE WHOLE AREA FLOODED.

They also "*especially commended the raising either all the streets, or the whole area subject to submergence, above the reach of the floods.*" "*The advantages,*" they remark, "*of so raising this section of our city, in point of safety, utility, and in every view as a public and private improvement, would be beyond all comparison over those of a mere dyke.*"

The reports of the engineers are more interesting even than that of the committee. Seth E. Marsh, city surveyor, makes a very brief statement that he had run the levels and supposed that General Ellis' quantities figured from them were correct. He does not see, however, where the General can get dirt at the prices used in his estimate.

EXTRACTS FROM ELABORATE REPORT OF JAMES LAURIE.

James Laurie, consulting engineer, makes the most thorough report that has yet appeared. It covers fifteen closely written foolscap pages.

He examines first the proposed route, criticizing only the part between Potter and State streets. *That through Commerce street he decidedly prefers to the one along the wharves,*

VIEW OF COMMERCE STREET DURING FRESHET IN THE CONNECTICUT RIVER. LOOKING SOUTHERLY FROM THE OLD FREIGHT DEPOT NEAR FOOT OF KILBOURN STREET.

This flooding nuisance, north of State street, eliminated and all buildings in the foreground on right of view destroyed for the location of Connecticut Boulevard by the Connecticut River Bridge and Highway District Commission.

but thinks that possibly an intermediate route might be desirable, as it would save erecting retaining walls along the street line of Commerce street. (This route, by the way, was the one favored later by the council. It ran somewhat west of the present Valley Railroad.)

OPINION OF JAMES LAURIE REGARDING ELEVATION OF TOP OF DYKE.

Regarding height of dyke, Mr. Laurie calls attention to the fact that the 1801 flood probably came within 20 inches of equaling that of 1854 and the 1862 flood within 14 inches, and says: *"I think it would be unwise to assume that there may not be higher floods. It is generally admitted that as the cultivation of the soil is extended and the country near the head sources of the river becomes stripped of its wooded covering, the melting of the snow, and the discharge of water into the streams becomes more rapid in consequence of the greater exposure to the action of the sun, and the removal of obstructions which accumulate in a wooded country to the free discharge of the water. There may not in the aggregate be a larger volume of water discharged by the river, but it is hurried more rapidly forward, thus producing higher floods."* He therefore advises that the crest of the dyke be made three feet above the 1854 flood (at elevation 34.4) instead of two feet, as Colt's dyke had been built and as was proposed for this dyke.

"I am aware," he concludes, *"how desirable it is for convenience of crossing, to keep the top of the dyke low, but looking at the disastrous consequences which would ensue should there be a higher flood than that of 1854, and a breach be made, I certainly would be disposed to make it about one foot higher."*

"Such works ought not to be undertaken unless they are constructed with all reasonable precautions and safeguards against the destruction of life and property."

The wells said to connect with the Connecticut River

were examined thoroughly, and from all indications he thinks "that a porous stratum, probably gravel, exists extending under a considerable portion of the district proposed to be dyked, and that it approaches nearer the surface as we proceed northerly from Little River. *Its depth or thickness is not known, and can only be determined by a series of borings, which I think it would be advisable to make.* . . . Should it be found that the depth down to a water-tight stratum is not great, a puddle wall, proportioned at one foot in thickness for every three feet of head would prevent percolation from the river; but if of great depth and extending over a large area it would be exceedingly difficult and costly to exclude the water. And I should endeavor rather by filling in the wells, old vaults, etc., which may have penetrated through the gravel, to reduce the quantity of water that could reach the surface inside, and by means of large sewers lead it off before it could flood the cellars."

"Sheet piling alone, while it would not prevent percolation, might prevent water channels from being formed underneath which would endanger the dyke."

"Within Colt's dyke there is a place near the outlet through Wawarme avenue where there is a considerable ingress of water by boiling up through the meadow during high freshets. In the 1862 flood the volume of water so entering was thought equal to that which would pass through a three or four inch pipe under a fifteen foot head. The water brought with it a considerable quantity of fine sand, and during the continuance of the freshet the dyke immediately opposite settled down about 1½ feet. The steam power used, about 10 or 12 horse power, was inadequate to pump this water, together with the natural drainage, and some of the cellars were flooded. There has been no higher flood since." This leak was stopped at the time (says Mr. W. L. Winship, superintendent for Mrs. Colt) by placing a deep layer of clay inside of the dyke over the porous ground, and has never reappeared.

Mr. Laurie agrees with General Ellis that the drainage of the district is important, but instead of allowing the rainfall "to remain upon the surface . . until it soaks into the ground or is evaporated" he recommends a storage basin which could hold the surplus until small pumps could lift it over the dyke. Under the Ellis plan the gates at Front and Ferry streets must be closed at elevation 15.6 and the sewage and rainfall pumped while the river stood above this level. This time may be expected to vary from two to five weeks, averaging about three weeks in each year, and it may occur in any month.

He estimates the sewage to be pumped at two-thirds of a water consumption of thirty gallons per capita by a population of 10,000; or if half is carried off in six hours it would equal 25,000 gallons per hour. Mr. Laurie abstracted the rainfall records kept by Prof. John Brocklesby of Trinity College from July 1, 1846, to February 28, 1854, and by Dr. W. S. Porter at the Insane Retreat and Charles J. Hoadley, State Librarian, since September 1, 1864, and notes that "a rainfall of one inch and over in twenty-four hours occurs about thirteen times in a year and that a rainfall of two inches and over occurs about three and one-third times in the same period." On July 27, 1866, he notes a fall of three and one-half inches in two hours.

He finds the same fault with these records that exists in all rainfall tables before the invention of the automatic registering gauges, that they "*exhibit rather the total quantity of rain falling during each rain storm than the greatest quantity in a given time,*" and gives the following records observed at Boston by Jonathan B. Hall, Esq.:

1823 — July 16th — There fell in 10 minutes 1½ inches of rain.

1829 — July 30th — A succession of heavy thunder showers each lasting 20 to 30 minutes; probably at each shower an inch of rain fell; in all five inches.

1835 — July 15th — A succession of heavy thunder showers, probably about an inch of rain fell in each shower, total 5.38 inches.

1845 — Nov. 27th — In 8 hours there fell 3.35 inches. Similar observations in Cambridge, Mass., by G. P. Bond, Esq.

1840 — July 23rd	— In	about	3 hours,	1.50 inches
1841 — June	"	"	3 "	3.50 "
1848 — Sept. 1st	"	"	1½ "	2.81 "
1849 — Nov. 19th	"	"	6 "	3.33 "

"In the early spring when freshets are most to be anticipated the ground is generally saturated with water, and but little of the water is absorbed, but is poured directly through its channels to the river. Neither is it an uncommon occurrence for the ground to be covered with snow, which melting rapidly, adds greatly to the volume of water. Such combinations of atmospheric phenomena are not of so rare occurrence as to allow of their being entirely disregarded. *A heavy fall of rain on top of a flood when the gates are closed must be provided for to insure immunity from damage. But I do not deem it expedient in the present case to provide for extraordinary rains which occur only at long intervals, as the chances are but small of there being a flood when they do occur.*"

He figures that the water reaching the sewers from a rainfall of one inch in one hour from the district south of Morgan street only, would require a 370 horse-power engine to lift it in that time. "But the first cost and maintenance of such an engine would be very great, and I consider a storage pond essential to the success of the dyke. With a storage pond capable of holding a rainfall of two or three inches the power of the engine may be reduced to the one-twenty-fourth, or to about 12 horse power."

In addition to the above is the district north of Morgan street, for which General Ellis had provided no pumping plant, relying on a fire engine to handle the small amount of sewage, and proposing to allow the rainfall to remain upon the surface until it soaks into the ground or is evaporated. Mr. Laurie points out that " a considerable portion of the district being meadow, or level ground, the rainfall would not accumulate in deep ponds, but would be distributed over a large surface. If it is not pumped out . . . the accumulation in two or three weeks might be considerable, and more especially if there should be percolation from the river to a greater extent than is carried off by evaporation and absorption within the dyke.

" The dyke under such circumstances would probably protect the upper portion of the districts from being flooded, but the lower would be liable to be submerged by the accumulation of rain-water and sewage; and I know of no practicable plan to prevent this except by having a storage pond to hold the greatest rainfall that is likely to occur.

" Within the Colt dyke there is a reservoir probably of fully 20 acres, of pond and meadow, capable of holding the heaviest rainfall for several successive days. They have also the advantage of being able to apply to the pumps as much power as may be found necessary from their large steam engine, besides the small one which has been added since the main building was destroyed by fire."

To secure the space necessary for a storage basin he proposes to swing the dyke easterly to about where the Valley railroad is now located and excavate a pit west of Riverside park of about 10 acres, which would hold a rainfall of three inches over the whole watershed and discharge it after the river has fallen to elevation 10.6. He would build a sewer through Commerce, Talcott, Charles, Morgan, and Front streets flowing north into this basin and intercepting all the existing sewers which discharge directly into the river.

The crossings over the dyke, as proposed by General

Ellis, are "perhaps the best the case admits." He would have no roadway less than 26 feet wide, and no slope greater than about five per cent.

In checking the cost estimates he adds $40,000 to the previous figures for raising the dyke one foot, puddling with clay in porous spots which may be found, and lengthening the dyke to enclose the proposed storage basin.

Referring to the method of construction he says: "Embankments to keep out water must be made with great care. When the material is pervious to water a puddle wall of clay becomes necessary in the middle of the bank. If made without a puddle wall it is necessary that the material be of a binding character and spread in thin layers and consolidated by the use of rollers and water, or by the tread of horses and wheels. Tipping from railroad cars is the worst manner of constructing a water-tight embankment, and carting the material by horses and carts and spreading it in thin layers of six to nine inches perhaps the best."

"Possibly the cheapest method (of procuring material) would be to purchase land, or the right to take material from the meadows north of the city waterworks. Where the land or right to take material can be purchased for $100 per acre, and five feet depth of material can be procured, the cost would be 1¼ cents per cubic yard."

JAMES LAURIE'S ESTIMATE OF COST OF DYKE $300,000.

"*Without entering into details of all the items of the estimate which until definite plans are adopted would only mislead, I would add, say one-fourth to the estimated cost of $234,675, making in round figures $300,000 as the probable cost of the work.*" Mr. Laurie's closing paragraphs are so precisely applicable to the present conditions that they particularly deserve quoting in full.

JAMES LAURIE ADVISES BORINGS TO DETERMINE NATURE OF SOIL.

"I have made frequent reference to Colt's Dyke, which, being immediately contiguous, would, if the nature of the foundation were the same, afford the most reliable data; and the success of that work might be taken as evidence of the practicability of carrying out the city project. But the whole question turns on whether the character of the underlying strata is the same or as good; and to determine which I propose that a series of borings and observations be made."

"The Colt's dyke enclosed a wide stretch of meadow, which from time immemorial had been covered by the Connecticut in high freshets. The city project proposes the enclosing of a tract of land which during the last 200 years has been filled in and built upon. The map of the city as late as 1824 shows Meadow Creek running inland about 250 feet from the line of the river to the foot of Kilbourn street; while from Ferry street to near Dutch Point the line of the river is near the present site of Commerce street. Much of this made ground probably consists of débris and refuse and cannot be relied on to form a water-tight barrier."

JAMES LAURIE'S ESTIMATE OF COST OF RAISING WHOLE AREA TO ELEVATION 32.4, $450,000.

"In view of the difficulties mentioned, which, however, may disappear under the experiments suggested, I have made some approximate calculations of the amount of filling that would be required to fill in the whole flooded area to a level one foot above the flood of 1854, and find the result as follows:

"District south of Morgan street and above Commerce street, 425,000 cubic yards; district north of Morgan street and above Front street, 700,000 cubic yards; total, 1,125,000 cubic yards; which, estimating at 40 cents per cubic yard, amounts to $450,000."

ESTIMATE DOES NOT INCLUDE RAISING OF STREETS AND BUILDINGS.

"To do this would give a permanent value to the property in these districts which no mere dyke can effect. In addition, however, to the cost of filling there would be a large expenditure required for lifting and relaying the paving and flagging, and raising and adapting the present buildings to the new grade. Eventually I have no doubt as to what would be the result, but as to whether such plan of improvement would give an immediate equivalent enhancement to the value of the property I can express no opinion. The plan has the advantage that it could be carried out in sections from time to time as might be thought advisable."

RAISING OF STREETS ONLY TO ELEVATION 32.4 WOULD ADD $137,500.

"To fill in the streets only of both districts to one foot above the flood of 1854 would require about 275,000 cubic yards and would cost about $137,500. Of course in neither of these cases would percolation from underneath be prevented except so far as the additional thickness and weight of material might reduce it, but by the raising of the grade the intention would be to abandon and fill up the present cellars."

GENERAL WM. B. FRANKLIN RECOMMENDS ELEVATION 34.4 FOR TOP OF DYKE.

General Wm. B. Franklin, in seconding the above report, under date of January 5, 1867, says:

"I think that Mr. Laurie's arguments for an increased height of dyke are conclusive and that the top of the dyke should be three feet above the level of the flood of 1854 . . "

"I have learned that Colonel Colt before the height of his dyke was determined had a thorough examination made of the valley of the river above Hartford and concluded that the quantity of water required to raise the water at Hartford one foot above the flood of 1854 would involve the flooding

of much country which has never yet been flooded and several times greater in area than that overflowed in 1854. He therefore determined the height of his dyke on this principle, and the proposed dyke, if built two feet higher than it, may be considered absolutely safe against overflow."

"I do not believe that the probabilities of heavy rains taking place when the river is so high that the dyke outlets are closed are great enough, nor the inconvenience arising from having the water from a heavy and sudden rainfall remain for twenty-four hours in the ground adjacent to the dyke severe enough to require the adoption of Mr. Laurie's plan at this time. I think that it will be better to adopt General Ellis' system of drainage and outlets, adding a stationary engine of, say, 6 HP. with pumps and gate at the foot of Pleasant street for disposing of the sewage and rainfall during the freshets of the district above Morgan street. After the completion of the dyke, if it should be found that the inconvenience from the want of a reservoir for drainage is too great it will be as easy to construct a reservoir then as now, and it is likely the cost will not be as great hereafter as it would be at this time."

GENERAL WM. B. FRANKLIN RECOMMENDS RAISING WHOLE FLOODED AREA.

"The concluding remarks of Mr. Laurie as to the advisability of filling up to the level of 1854 the whole district subject to overflow seemed to me to invite the particular attention of the committee and of the city. In any event should the dyke be built, I believe that the grades of the streets in the flooded districts should be raised to about the level of its top, so that new buildings would be constructed to correspond to those grades. In a few years the whole of the flooded district would by this means be lifted above all danger of overflow, and all of that part of the town would be so materially improved in value that the cost of the change would be much

more than reimbursed to the city and the owners of the property."

RESOLUTIONS LAYING OUT DYKE KILLED.

The foregoing reports were submitted to the council, January 28, 1867, and tabled for printing. On May 13th, they were taken up and again tabled, together with a resolution raising a committee to study the same and report a resolution "for carrying of their reported plan into effect." At the next meeting, however, the committee consisting of two aldermen and five councilmen was appointed.

On August 12th a resolution was ordered published directing the highway committee to proceed in conformity to law and lay out and construct the dyke (the highway committee had reported this layout July 9, 1866), on the Commerce street route. At the next meeting the aldermen amended this order, by a vote of 6 to 5, to the route recommended by Mr. Laurie east of Commerce street, and at the following meeting, September 9th, the councilmen voted to indefinitely postpone. The aldermen with the mayor breaking a tie refused to concur and as the council would not recede, the whole matter was killed.

NEW PETITION PRESENTED FOR DYKE.

A new petition was promptly introduced (October 14, 1867), and referred to the highway committee. Here it lay until December 23d, when a report being called for they recommended the Laurie route, and were promptly told that the Commerce street route was the one desired.

On January 13, 1868, accordingly, "agreeable to instructions from the Court of Common Council," the committee reported a resolution laying out the dyke "as recommended by the special committee, August 12, 1867."

The councilmen, however, indefinitely postponed action and the aldermen this time concurred.

VIEW OF LOWER MORGAN STREET DURING FRESHET IN THE CONNECTICUT RIVER. LOOKING EASTERLY FROM NEAR THE CORNER OF FRONT STREET.

This flooding nuisance eliminated by change in grade of Morgan street made by the Connecticut River Bridge and Highway District Commission. All buildings on left of View destroyed for location of New Freight Yards. All buildings on right of View also destroyed for location of Connecticut Boulevard and for the widening of Morgan street.

CONSTRUCTION OF VALLEY RAILROAD DELAYS ACTION ON DYKE.

Still undismayed the petitioners again introduced the subject May 11, 1868, but it seems to have slumbered in the hands of the highway committee until October 11, 1869, when a demand was made for a report at the next meeting of "all petitions relating to the dyke they may have before them." These were referred to a joint special committee who reported November 22, 1869, "that they deemed it inexpedient to recommend any action in regard to said dyke until the terminum of the Valley railroad is decided upon."

NEGOTIATIONS WITH VALLEY RAILROAD ON CONSTRUCTION OF DYKE.

After the completion of the Valley railroad in 1870 a special committee on the dyke was organized on April 18, 1870, empowered to negotiate with the officers of the Connecticut Valley Railroad Company or others and to build said dyke "upon some mutual plan."

Apparently it was thought that they could accomplish something, for it was provided that the senior councilman should "be present at all conferences with said railroad officers and others, and keep a minute account thereof and report the same to the committee in full, they reporting to the council without unnecessary delay."

Again on June 20, 1871, a different committee was appointed "to confer with the Connecticut Valley Railroad Company and ascertain upon what terms said railroad company will co-operate with the City of Hartford in making their embankment upon the east side of the city answer the purpose of a dyke."

ORGANIZATION OF BOARD OF STREET COMMISSIONERS DELAYS ACTION ON DYKE.

No report from either committee is on record, perhaps for the reason that at about this time the city charter was radically changed by the creation of the Board of Street

Commissioners (organized May, 1872). Many of the duties heretofore undertaken by committees of the Common Council were turned over to them. On them probably would have fallen the work of negotiating for the dyke, but other affairs engrossed their attention, the matter was not pressed by interested citizens, and no action has ever been taken by them.

MAYOR MILES B. PRESTON REVIVES AGITATION ON DYKE.

Mayor Preston was responsible for the next public agitation of the subject. In his annual message of 1896 he especially mentioned the importance of the permanent reclamation of the district and invited the "earnest consideration of this subject, with a view of formulating a plan whereby the entire lower portion of the city may be raised above the flood line."

COMMITTEE APPOINTED TO CONSIDER MAYOR PRESTON'S RECOMMENDATIONS.

At the first business meeting of the Common Council thereafter, April 27th, a committee was appointed "to take that part of the mayor's message that relates to protection of the river front into consideration and report its finding to the board." A petition signed by forty-eight of the most prominent owners and business men of the east side was also introduced, praying for action and offering their full co-operation.

PRESTON COMMITTEE THINK DYKE GOOD INVESTMENT, BUT RAISING OF FLOODED STREETS TO ELEVATION 32.4 BETTER.

The committee reported, June 22d, that they thought the dyke feasible, and a good investment. They favored as far more desirable, however, the gradual raising of the streets to elevation 32.4 and they reported a resolution directing the street board to spend not exceeding $10,000 each year for the purpose.

This report was accepted and referred to a committee of the whole for a public hearing, which was held October 6th and was largely attended. November 9th the committee of the whole referred the matter of the $10,000 annual appropriation to the ways and means committee who held another still more successful public hearing and reported, February 8th, that the joint standing committee on river front would better be discharged and the whole matter referred to the street board. A resolution to this effect was carried. The then uncertainty of the location of the new bridge and its approaches rendered definite action unwise and nothing more was done until the beginning of the present movement.

SIMILARITY OF PLANS.

From a careful study of the foregoing reports of engineers and committees, extending over nearly a half century, it will be seen that practically all agree that the solution of this important problem lies in the construction of an impermeable dyke around the inundated district, and an intercepting sewer or system of sewers within its limits, to collect and carry the sewage and ground-water to a central pumping station from which it would be lifted over the dyke during high water stages.

The reports disagree to a limited extent as to the location and height of the proposed dyke. There also seems to have been quite a difference of opinion in regard to the location of the proposed relief sewers and pumping stations. Some advocated the raising of the entire area, others that of the streets only, believing that the different owners would eventually raise their properties to the new street grades.

Mr. Edwin D. Graves, chief engineer of the Hartford Bridge, investigated the river front sewerage problem in connection with his studies of the bridge problem, and decided that the sewage could best be collected by means of an interceptor, paralleling the river, and carried far enough

south to render pollution of the immediate river front unobjectionable.

WORK OF THE CONNECTICUT RIVER BRIDGE AND HIGHWAY DISTRICT COMMISSION.

Few people realize, I think, the vast amount of work which has been done during the last decade by the Connecticut River Bridge and Highway District Commission toward a permanent abatement of the flooding nuisance, caused by freshets in the Connecticut River. I consider this work of the Bridge Commission second only in importance to the union of the eastern and western sections of this state with a stone bridge spanning the Connecticut River, which is as enduring as it is artistic, graceful and monumental. I well remember the many tenement houses on North Front street and lower Morgan street which were always flooded by unusually high freshets. I have seen North Front street from Morgan street to Pleasant street, and Morgan street east of Front street flooded to a sufficient depth, since 1896, to compel tenants to navigate from house to house in rowboats. Today this entire section is wiped out and replaced by a modern, spacious freight yard above freshet level. The entire area from State street northerly to the Highland Division of the N. Y., N. H. & H. R. R. Co. is enclosed by the raising of State street from Front street easterly, and the construction of Connecticut Boulevard and the new Valley Railroad embankment north of Morgan street.

The filling work done by the Bridge Commission is of direct benefit to the inundated district, as a large portion of it would have had to be done by the city later, if not included in the permanent work of this commission, so that a part of this work,— that of raising State street and the construction of Connecticut Boulevard, serves a double purpose. It prevents surface flooding from freshets in the Connecticut River, and forms the westerly approach of Hartford Bridge.

THE PROBLEM OF 1908.

From the above it will be seen that from the physical standpoint, that portion of the problem north of State street has been radically changed and greatly simplified by the work of the Bridge Commission during the last decade. The section south of State street, however, remains practically unchanged.

In one other respect, that of property ownership, there is a marked contrast between the condition of today and that of 1865. Then, eighty-two persons were willing to pay their share of the entire cost of the proposed dyke. At that time there were few owners of large properties; today there are many owners, and mostly of small properties.

The dyking part of the problem is now all completed north of State street, so that the construction of a dyke south of State street to Park River will complete that portion of the problem.

METHODS OF TREATMENT.

The improvement of sanitary conditions on the East Side, so called, has two primary objects: First, the prevention of sickness, suffering and financial damage from freshets in the Connecticut River. Secondly, the reduction to a minimum of pollution in the Connecticut River and the removal of the increasing unsightliness and objectionableness from the discharge of crude sewage from local sewers along the immediate river frontage. The latter object may be attained by a proper solution of the former problem, and may, therefore, be considered of secondary importance. The immediate and permanent abatement of the flooding nuisance appears to be the great and pressing problem.

FLOOD HEIGHTS.

Flood heights in the Connecticut River at Hartford are popularly referred to zero of the "Toll House Gauge," the

been passed, after which the surplus water, so stored, can be gradually released without injury to persons or property below. The difficulty of carrying out this plan is due to the fact that most large rivers cross several adjoining states, and the co-operation of all interests necessary for the successful accomplishment of this plan cannot easily be obtained. This is especially true of the Hartford problem in its relationship to the Connecticut River. Storage reservoirs to sufficiently confine the flood flow of this stream so as to reduce freshet conditions in Hartford would have to be built in some of the states to the north of Connecticut.

Secondly, by the removal of obstructions to the normal discharge of rivers. Occasionally temporary ice jams produce serious freshets in the dead of winter, the worst possible period. Other obstructions are caused by the gradual accumulation of débris brought down by streams during flood flow, the débris itself, in many cases, representing an inexcusable waste and financial loss.

It has been suggested that the widening and deepening of the Connecticut River channel at the Narrows near Middletown would tend to lower the hydraulic grade of the river as far north as Hartford, and thus reduce the freshet trouble to quite an appreciable extent. While I have not made a detailed study of the effect which would be produced here by the execution of such a plan, my impression is that very little, if any, improvement would result. It would no doubt reduce the hydraulic grade for some distance north of Middletown and possibly better the river conditions in the vicinity of the improvement, but I very much doubt if it would be of sufficient help in the solution of the local problem to warrant the city in promoting such a plan for this particular purpose. If successful, it would help only a little in solving the flooding problem, and what we want is not a partial but a permanent abatement of this nuisance.

Thirdly, by the construction of local flood protection works, to confine the flood flow in artificial channels. Un-

30.56 (U. S. A. 29.0), or 10 inches below the 1854 freshet. If the protection is carried higher, the reduction in probable damage should represent a fair interest on the additional capital invested in the improvement. It should be remembered, however, that the damage from a flood above the protected height after the improvement, would be much greater than the present flood losses. Cellars now empty, because of anticipated freshets, would then be filled with perishable goods. Confidence in the adequacy of the protection must be absolute if rentals and realty values in the district are to increase, as they should, after the completion of flood protection works.

FLOOD HEIGHTS UNCERTAIN.

Freshets are caused by a combination of circumstances, and the most uncertain feature in connection with a study of this problem is the fact that we have no way of knowing that a certain combination of favorable conditions may not produce even greater freshets than any heretofore experienced. If it is true, as generally admitted, that the deforestation of the land at the head waters of streams is partially responsible for disastrous flooding nuisances, then there is a double loss. The country is being deprived of the scenic beauty of mountain vistas and of the influence of virgin forests upon the gradual distribution of water from catchment areas, while along the lower reaches of the rivers, much sickness, suffering, and financial loss is annually experienced from the unequal and uncertain distribution of water from the watershed above.

FLOOD PREVENTION METHODS.

The prevention of flooding nuisances is most effectively accomplished by artificial means by any one or a combination of the following methods: First, by the construction of huge reservoirs in favorable locations upon the upper tributaries, to confine the flood flow until the critical stage has

SEWERAGE DISTRICTS.

Beginning on the south the river front district may be divided into sections all bounded west by land above flood level as follows:

1. Colt meadow section, extending from Warwarme avenue to Park River.

2. Commerce street section, extending from Park River to State street.

3. Boulevard section, extending from State street to Morgan street, along the boulevard approach to Hartford Bridge.

4. Windsor street section, from Morgan street to the N. Y., N. H. & H. R. R., in which Windsor street is the most damaged.

5. Northeast section, from Suffield street to Tower avenue, including the lower portion of the territory drained by the "Northeast" sewer system.

The Colt meadow section is already dyked, but the sewer pumps operated by the Colt Patent Fire Arms Company are wholly inadequate to handle surface water. Several years ago a rain occurred, while the river was high, and flooded this section, damaging the Colt Memorial and making a lake which could not be drained until the water in the river receded. There is great need of a pumping station for this district. It can best be designed in connection with other work to be described later.

The treatment of the Commerce street section should be the same as the plan adopted for the boulevard and the Windsor street sections. The change in the grade of State street and the construction of Connecticut Boulevard and the railroad freight yards and track embankments north of Morgan street have completely dyked the boulevard and Windsor street sections to elevation 30.5 (U. S. A. 29.0). They will, therefore, be treated together hereafter. In making these great improvements, no changes have been made in the old sewers in these two districts. They still pierce the filling

VIEW OF NORTH FRONT STREET DURING FRESHET IN THE CONNECTICUT RIVER.
LOOKING NORTHERLY FROM MORGAN STREET.

This street discontinued and all buildings destroyed by the Connecticut River Bridge and Highway District Commission for the location of the New Freight Yards of the N. Y., N. H. & H. R. R. Co.

and embankments at State, Kilbourn, Ferry and Morgan streets, as do also the Gordon Lane and northeast sewers and other private drains at unknown points. A dyke is useless if the water can back through these sewers and flood the low area within. This section can be raised or the water can be kept out. We have now come to the immediate, detailed application of the question: Shall we dyke or raise the Boulevard and Windsor street sections from State street to Avon street?

DYKE.

To make an efficient dyke of the boulevard embankment and prevent all flooding in the boulevard and Windsor street sections, the present sewer outlets need only to be stopped and the sewage and storm water pumped through the dyke when water in the Connecticut River is high. The embankments have not been built with any especial regard to their action as dykes, and it is possible that the original soil under them, the material of which they are constructed, or the manner in which this has been placed in the fill, may be such as to allow river water to seep through during high floods. Some of the land was filled years ago, perhaps with very loose material, and there is also the probability that a layer of porous sand or gravel may lie near the surface. If an investigation shows this to be the case, it will nevertheless be possible to build cores of clay or concrete which will make the dykes perfectly impervious. Fifty years ago it was feared that the meadow silts and sands underlying the meadow district would allow the water to percolate to a dangerous extent, but the success of the Colt meadow dykes has exploded this theory.

RIVER FRONT INTERCEPTOR.

A pump might be placed at each street where an old sewer pierces the dyke, but it can be shown that the increased cost of housing and tending so many small units would prob-

ably be greater than the cost of an interceptor to concentrate the flow from all at one or more points. An interceptor would also accomplish the second principal object of the improvement, viz., the cleaning up of the river front, because it would eventually be built far enough south to carry the river pollution below the city. The time is surely coming when the sewage of this city must be filtered before entering the Connecticut River, and as the south meadows are probably the best place for purification works, the river front interceptor should be considered with reference to its ultimate extension toward that location. As the outlet of the northeast sewer is even lower than the south meadows, pumps are necessary in any event. They may be (1) all at one point, or (2) at several places along the proposed interceptor. Under conditions (1) they must be near the southerly end, because if the sewage were lifted at the northerly end high enough to discharge by gravity at the meadow end, the interceptor would be too shallow to intercept the local sewers or to provide suitable drainage for the abutting properties along its route. The grade must start at the northeast sewer and descend uniformly to the south meadows. Pumps there with one lift could raise the sewage to the river level, or later to filtration beds.

Under plan (2) pumps could be located at the most suitable places along the route. Perhaps the best plan provides for three lifts. The first pump could lift the sewage at the northeast sewer about 13 feet, or high enough to enable it to flow by gravity to the outlet of the Park River Valley interceptor at Keney Lane; another pumping station at the junction of the East Side River Front, and the Park River Valley interceptors near the corner of Potter and Commerce streets could lift the sewage from both, and enable it to flow by gravity to an outlet at the South Meadows, while the third set of pumps at the meadow outlet could lift the sewage above freshet level or to the purification plant.

The great advantage of this three lift, over the one lift plan are:

First: It need not be operated continuously, for at low water the sewage could discharge by gravity at Keney Lane, while with the one lift plan the pumps must be run most of the time to get a satisfactory discharge.

Secondly: A break-down would affect a district only one quarter as large.

Thirdly: This plan could be carried out in sections as needed.

To accommodate the Commerce street, Boulevard, and Windsor street sections, under either the dyke or fill plan, only two pumping plants, one near the Park River Valley interceptor, and one at the northeast trunk sewer, are required.

When the pollution of the Connecticut River below Keney Lane requires it, the larger pumps necessary to handle the sewage of the Park River Valley interceptor could be installed, and the more expensive extension across Park River could be built. Until then, both the cost of construction and operation of this part would be saved. The pumps proposed for the three lift plan would still be large enough to operate economically. This plan provides for a river front interceptor to start at the foot of Keney Lane or Potter street, where it would temporarily discharge into the Connecticut River, thence to run westerly to Commerce street; thence northerly through Commerce street and Connecticut Boulevard to Kilbourn street; thence westerly in Kilbourn street to Charles street; thence northerly in Charles street to Talcott street; thence westerly in Talcott street to Front street; thence northerly in Front street to Morgan street; thence westerly in Morgan street to Market street; thence northerly in Market street to Pleasant street; thence westerly in Pleasant street to Village street or Windsor street; thence northerly in Village street or Windsor street to Avon street, its northerly terminus.

This sewer would be laid out to discharge by gravity, at about elevation 6.0, until water in the Connecticut River rose to about elevation 15, seventeen being the elevation of the lowest cellar upon the route laid out for the river front interceptor. If the Connecticut River continued to rise, the gates at the outlet would be closed and pumps of sufficient capacity to handle all sewage and surface water from the area enclosed by the dyke, would be started and operated continuously until the water in the Connecticut River receded to elevation 15. This interceptor would be of varying sizes from about seven feet in diameter at the outlet to about four feet at the northerly end. (Sizes given in more detail in another part of this report). The grade of the interceptor would be one foot in each one thousand feet, or similar to the grade of the Park River Valley intercepting sewer. The depth would be sufficient for ordinary cellars, and considerably deeper than the present local sewers to be replaced by the proposed interceptor. The line of the interceptor as indicated herein follows along the foot of the slopes of the drainage basin or through streets which are most in need of better sewerage facilities.

Before the bridge improvements were carried out, Mr. Graves, the chief engineer, secured an agreement from the N. Y., N. H. & H. R. R. Co., permitting the construction of the proposed east side interceptor across the new freight yards north of Morgan street to connect with the northeast sewer, practically on a line with Charles street extension. At that time it was planned to bring the sewage by gravity from the northeast sewer through the new sewer in the freight yards, to the corner of Charles and Morgan streets, where a pumping station would lift it to the higher level sewer.

It now seems impracticable to carry out this part of the system as then planned, on account of the increased difficulty and additional expense. The extra cutting through Morgan street and the new freight yards at their present grade would

make an appreciable difference in the cost of this section, and work around the network of freight tracks would be difficult.

Partly for this reason and partly because the old local sewers in Front street, Morgan street, Market street, Pleasant street, and Windsor street, are too shallow and defective to furnish suitable drainage, the line of the proposed interceptor has been changed, from that originally planned, from the corner of Charles street and Talcott street northerly. The new interceptor through these streets would be larger and deeper than the local sewers, and would provide this congested district with adequate sewerage facilities so much needed at the present time. If the interceptor followed some other location, all of these local sewers would have to be rebuilt at an early date. A choice in the location of the interceptor north of Pleasant street between Village and Windsor streets, depends upon whether the need of a new sewer in Village street, which has none at present, is greater than the need of a new sewer in Windsor street to replace the present shallow, inadequate sewer. If the latter route is followed, and Village street north of Pleasant street builds up, a local sewer discharging into the interceptor at Pleasant street could be provided for this part of Village street. While the interceptor could be constructed through the Village street route with less inconvenience to highway traffic and business interests, I believe the Windsor street route would produce much greater immediate benefits. If the modified route of the east side interceptor from the corner of Charles and Talcott streets to the northerly terminus is adopted, new local sewers discharging westerly into the new interceptor, instead of easterly into the northeast trunk sewer, would be required in Pleasant street, between Market street and the new freight yards, and in North street, Pequot street, and Avon street; but all of these except the latter would be of small size, comparatively short, and inexpensive.

SMALL PUMPING STATION ON NORTHEAST SEWER.

It is planned to construct a small pumping station, possibly to work automatically, near the corner of North Front street and Avon street, to lift the sewage from the northeast sewer, and to discharge it westerly through the new Avon street sewer, into the northerly end of the river front interceptor at Village street or Windsor street. On account of the low grade, and large size (60 inches) of the northeast trunk sewer, it seems entirely impracticable to attempt to carry its entire discharge by gravity through the new river front interceptor. The increased cost due to excessive depth and sizes would be prohibitive.

During severe storms the small pumping station at Avon and North Front streets would become overloaded and the excess surface water, slightly polluted, would pass out through the northeast trunk sewer into the Connecticut River between the new Hartford Bridge and the waterworks pumping station, as it does at present.

PUMPING STATION AT COMMERCE AND POTTER STREETS.

It is proposed to locate the principal pumping station at the intersection of Commerce and Potter streets, near the junction of the Park River Valley and the proposed river front intercepting sewers. This site is selected for the double purpose of handling the sewage and surface water from the river front interceptor, while the outlet gates are closed during freshets in the Connecticut River, and for lifting the sewage only from both interceptors, when the Connecticut River is below elevation 15, and discharging into a higher level sewer to be constructed later as an extension of the river front interceptor, either to a new outlet or to filter beds further down the river.

Even if the river front interceptor were to be extended at this time south of Park River, say to opposite the easterly end of Charter Oak avenue, or even below this point, it would be necessary to have a pumping station near the corner of

Commerce and Potter streets to handle the dry weather discharge of both interceptors because the extension from here southerly would have to be at a higher level. The storm water overflow through Keney Lane or Potter street seems essential in either case, because the cost of carrying the large sized river front interceptor below this point would be prohibitive.

While no one would question the desirability of building the extension to the south meadows at the earliest possible date, so as to remove all of the city's sewage from the immediate river frontage, it is not included in the present plan on account of the extra expense involved. The completion of the sewers herein indicated would at once abate the flooding nuisance between State street and Avon street, and this appears to be a pressing need.

RAISING COMMERCE, POTTER AND ARCH STREETS TO FORM DYKE.

The problem between State street and Park River, however, would not be completely solved by the construction of the river front interceptor, because a considerable portion of this area is below freshet level, and surface flooding would continue. The construction of this interceptor should, therefore, be followed by the raising of Commerce street between State street and Park River, and possibly Potter street between Commerce street and Front street, and small sections of Front and Arch streets near their intersection. This would completely dyke the entire area north of Park River and west of Commerce street, Connecticut Boulevard, and the Valley railroad embankment north of Morgan street. There still would remain an unprotected area east of Commerce street and between Park River and State street. Quite a large portion of this area is now used for wholesale purposes, and the owners, for the protection of their own properties, will gradually raise them above freshet level. The small residential section between Keney Lane and Park River could

be raised above freshet level if it continued to be used for residential purposes, but as this land is becoming more and more valuable each year, on account of the scarcity of river wharfage, it is probable that this section will soon change into a business district and be raised by the new owners.

RAISING WINDSOR STREET AND WINDSOR AVENUE TO FORM DYKE.

There is still another section of the city where flooding occurs from freshets in the Connecticut River, but owing to its undeveloped character, the freshets cause comparatively little damage or inconvenience at present. As this district develops, the trouble from this source will naturally increase. The area referred to is between Suffield street and Tower avenue and adjacent to Windsor street and Windsor avenue. This trouble can be entirely eliminated by raising the grade of Windsor street and Windsor avenue where water now overflows, and thus form a dyke of these two streets. This work could be carried out now, while the adjacent property is undeveloped, much more advantageously and economically than in later years.

STORM WATER INSIDE OF DYKE.

It may be stated as a general proposition that the most severe freshets follow a hard rain. Snow melted at the headwaters of the river increases the flood, but if melted by warm air only, it seldom produces dangerous flood heights. It is also usually true that by the time the river has risen say to elevation 15, the rainfall which produced the freshet has stopped, at least in Hartford, and the water has drained away from the surface of the ground. For these reasons it is sometimes argued that it is unnecessary to provide for pumping out rain water from inside the dyke, as it will never rain hard during high water in the Connecticut River; but occasionally a rain does come before the river has fallen below the danger line, and pumps must be provided to care

for it. It is nevertheless reasonably certain that the maximum rainfall and the maximum flood height will seldom come at the same time, and a great saving can be made by allowing for this. The present sewers in the section between Grove street and Canton street now take the rain water from all the side hill sloping toward the east from Main street, and under the dyke plan this water must be carried by the proposed interceptor at all times, regardless of the stage of the river.

CONSIDERATIONS AFFECTING THE DESIGN AND SIZE OF INTERCEPTOR.

The amount of rain water which must be cared for by the proposed river front intercepting sewer is difficult to estimate precisely. Data bearing upon this point have been accumulating for the last forty years, but only within ten years have automatic rain gauges made it possible to secure really valuable observations. On a great many points the available information is still very meagre.

The amount of rain which may be expected to fall in Hartford is shown on the accompanying diagram. It is well established that the most severe rates of precipitation are of short duration. The diagram shows that while rates of over 4.4 inches per hour have occurred lasting for ten minutes, not over 1½ inches has ever fallen in any one hour. A heavy rainfall lasting only six minutes would not seriously flood the sewer we are considering, because its length is so great that the water falling on the lower part of the district would have time to pass through the sewer and escape into the Connecticut River before the rain water from the Windsor avenue end of the district reached the interceptor at all. It is estimated that about twenty minutes must elapse before water from all parts of the district is being discharged at the outlet of the sewer. The maximum rate of rainfall to be expected in twenty minutes is, then, the rate which will be most likely to overload the sewer. From the consideration

of Hartford rainfall records and records of a number of other gauges all over the country, it is thought that the curve on the diagram indicated by a series of dashes will envelop any storm which is likely to occur here. A sewer figured for a rainfall shown by this curve will have capacity to carry even so exceptional a storm as that of October 8 and 9, 1903, which flooded New York and the Passaic valley so disastrously. This curve is represented by the formula $i = \frac{15}{\sqrt{t}}$ and gives for a time of twenty minutes an intensity or rate of precipitation of 3.35 inches, which is the maximum probable rainfall most likely to overload the sewer. The amount of rain water which will reach the sewer depends not only upon the rate of precipitation, but also upon the size, shape and slope of the drainage area, the amount covered by buildings, streets, and other impervious surfaces, and the condition of the soil in the yards or pervious surfaces. If it has been raining for some time the surface of the ground will have become saturated and a greater percentage of the rainfall will reach the sewers than if the ground is dry. It is a fact that the heaviest storms occur in summer, usually when the ground is driest, and for this reason do not produce the disastrous floods which would follow if a rain of equal intensity fell on frozen or snow- or ice-covered ground in the winter. The heaviest winter rain recorded in Hartford produced a rate of .6 of an inch an hour for 30 minutes.

The winter storm of March 10 and 11, 1901, had a maximum rate of only .8 of an inch per hour for ten minutes, yet the flood produced by it in the Franklin avenue district was much worse than that of July 11, 1901, when rain fell at the rate of four inches per hour for twelve minutes. A rain might fall at the rate of 4.25 inches per hour on a dry surface which would absorb two-thirds of it and therefore yield a run-off of 33 per cent. Such a storm would never occur in the winter; but a rate of 1½ inches per hour might occur at that season and the 95 per cent. which might run off would load the sewer to the same extent. The following

VIEW OF LOWER STATE STREET DURING FRESHET IN THE CONNECTICUT RIVER,
LOOKING WESTERLY FROM VALLEY RAILROAD (Post-office in background).

This flooding nuisance eliminated by change in grade of State Street and construction of Connecticut Boulevard by the Connecticut River Bridge and Highway District Commission.

percentages of run-off would practically all result in the same flood through the sewers.

95	per cent.	run-off	during	1½	inches	per hour	rain.
70	"	"	"	2	"	"	"
52	"	"	"	2.7	"	"	"
40	"	"	"	3.35	"	"	"
33	"	"	"	4.25	"	"	"

On the impervious surface of the watershed there is practically no absorption, but it takes a very considerable time for water from all parts of the sidewalks and other flooded areas to reach the sewers, so that the flood increases steadily as long as the rain continues constant until all of the area is contributing and the water reaching the sewers is equal to the amount of the rain falling on the impervious surfaces. If C represents the percentage of run-off and t the time in minutes since the beginning of the rain at the rate under consideration, the equation $C = 0.233 \sqrt[3]{t}$ has been proposed to represent the rate at which the run-off increases during the storm; or $C = 0.175 \sqrt[3]{t}$ for the average run-off. (See Gregory on Rainfall and Run-off, Trans. Am. Society C. E., Vol. 58, page 481.) This means that after it has rained for 80 minutes the run-off will equal the rainfall, while if the rain continues at the maximum rate for less than 80 minutes the run-off in any one minute is never equal to the amount of rain. Applied to our sewer where t equals 20 minutes, this will make C equal 47 per cent. for the amount of rain which will be discharged at the mouth of the sewer from the impervious surfaces at the end of the period of maximum rainfall.

If this section ultimately becomes a warehouse or closely built-up tenement district, as it is liable to, there might be 90% of impervious surface — such conditions exist in New York. This would make the coefficient of run-off from the impervious area equal to 90% of 47% of the maximum rain-

fall of 3.35″ per hour or in the formula $Q = cr\sqrt[4]{A^3S}$ cr would equal, disregarding the pervious surfaces, 1.42.

The area of the district contributing to the sewer affects the amount of water to be carried, but not as greatly as might be at first apparent. An area of 200 acres will not require a sewer twice as large as an area of 100 acres. The slope of the ground also affects the time required by the water to reach the sewers, and if the area is large so that the rain may cease before all of the sewer is contributing water at the outlet, the slope may become a very important factor.

The oldest and most generally accepted formula for run-off, that known as the Burkli-Ziegler, expresses the relation by $Q = cr\sqrt[4]{A^3S}$ where c and r refer to the percentage of run-off and the rate of rainfall, A is area and S the average slope of the ground in feet per thousand. Later formulas do not change the relation between slope and area very greatly. McMath's formula for St. Louis is $Q = cr\sqrt[5]{A^4S}$ Herring's formula for New York is $Q = cr\ A^{0.83}S^{0.27}$; and Gregory's formula suggested in 1907 is $Q = cr\ A^{0.86}S^{0.187}$.

The slope of the district varies from 0 in the direction of the river to 6% for a short distance at right angles to this on Morgan street. The average slope, measured along the lines which the water would follow, first in reaching the sewer inlets and later through the sewers themselves, would certainly be not greater than 3%, and this rate is to be assumed in figuring the sizes of the sewers. Taking the coefficient cr as derived above at 1.42 and the area contributing to the outlet at Keney Lane as 160 acres, the Burkli-Zeigler formula shows a probable discharge of 149 cubic feet per second; McMath's formula 163; the New York formula 240; and the Gregory formula 213. The greatest difference in estimates of sewer sizes comes from the choice of the rainfall and run-off coefficients. Where in some cases a rainfall of 2.7″ and a run-off of 70% has been assumed.

in others a rainfall of 2″ and a run-off of 50% has given apparently adequate sizes.

Using the quantities recommended by Herring for the densest part of New York City, $r = 3.28$, $c = 0.50$, in his formula, a discharge of 278 cu. ft. per second is indicated at the outlet. Using the formula he suggested for Hartford at the time the Park River interceptor was constructed, $Q = cr \sqrt[5]{A^4 S}$ with $c = 70\%$, and $r = 2.7$, we obtain a run-off of 217 cubic feet per second. The lately suggested Gregory formula $Q = cr\ A^{0.86}\ S^{0.187}$ with $c = 42\%$ and $r = 3.35$ gives 213 cu. ft. per second. Using the older and better established Burkli-Zeigler formula with a run-off of 70% of a 2″ rainfall we obtain 147 cu. ft. per second as the greatest probable discharge.

Owing to the fact that the district will be surrounded by a dyke it is impossible to figure on the water running away over the surface of the ground as it would do in districts not so enclosed. There is a way of accomplishing the same result, however, in a safer way by keeping the outlets of the present sewers open to the river and connecting them with the new sewers at an elevation just above its top. These old sewers would serve as overflows or safety valves in case of an overload, when the Connecticut River was normal. They would be connected through self-closing valves which could be made perfectly safe against leakage from flood water but their installation is not recommended in the detail design of the sewer. These relief valves could later be installed at a small expense, if considered necessary. By being able thus to discharge extreme storms through outlets at Grove, State, Kilbourn, Ferry and Morgan streets, we would avoid the necessity of building the sewer large enough to accommodate the exceptional storms which may occur once in 25 years. The formulas giving the lower quantities I believe to be sufficient for all ordinary conditions.

Using the Burkli-Zeigler formula, therefore, $Q = cr\sqrt[4]{A^8S}$ with C equals 0.70, R equals 2.0, and S equals 30, the following quanitities are obtained:

District (streets)	Area in acres	Flow cu. ft. per second.	Size of sewer required.
Above Cor. Windsor and Avon Sts.,	26.5	39	3′ 9″
" Windsor and Pleasant Sts.,	56.5	70	4′ 9″
" Market and Morgan Sts.,	71.5	81	5′ 0″
" Talcott and Front Sts.,	91.4	98	5′ 6″
" Kilbourn and Charles Sts.,	100.4	104	5′ 6″
" State and Commerce Sts.,	121	114	5′ 9″
" Commerce and Grove Sts.,	1.31.5	128	6′ 0″
" Commerce and Keney Lane,	160	149	6′ 3″

The above sewer capacities are figured on the assumption of the coefficient of friction N 0.013 in Kutter's formula for a similar brick sewer laid on a grade of 1 in 1000 feet. Using McMath's formula $Q = cr\sqrt[4]{A^4S}$ with $R = 2.7$ and the other constants as above, the required capacities and sizes would be as follows:

Location.	Flow cu. ft. per second	Size of sewer required.
Windsor and Avon Sts.,	52	4′ 3″
Windsor and Pleasant Sts.,	94	5′ 3″
Market and Morgan Sts.,	114	5′ 6″
Talcott and Front Sts.,	136	6′ 0″
Kilbourn and Charles Sts.,	150	6′ 3″
State and Commerce Sts.,	180	6′ 9″
Commerce and Grove Sts.,	187	6′ 9″
Commerce and Keney Lane,	217	7′ 0″

With the possibility of using safety valves at frequent intervals below Morgan street the smaller sizes might be reasonably safe, but north of Morgan street a 5-foot 3-inch sewer to the corner of Windsor and Pleasant streets with a 4-foot 3-inch sewer from Pleasant to Avon streets should be used. There is serious flooding at present in this district and the slopes are steeper and closer to the intercepting sewer than at other points.

When the water in the river stands near the elevation of the lower sewer it will of course be necessary to pump all rain water in the district. In deciding upon the amount of this water likely to be pumped, a diagram has been plotted showing the rains which have actually occurred during periods of high water since the automatic gauges were installed at City Hall. From these diagrams it is obvious that heavy rains precipitating over 3 inches have occurred during periods of high water. It is probable, however, that *exceptional* storms would occur before rather than after the period of highest water, as the flood is the result of a heavy rainfall. It is also probable that rains having the greatest rate of precipitation, say above 3 inches per hour, would come in the dry, thunder shower period rather than at a time when the river was high and the air saturated with moisture from previous storms. It is believed to be safe to figure on having to pump rainfalls of not over 2 inches per hour if a high figure, say 70 per cent. is assumed for the run-off coefficient to cover winter conditions. This is equivalent to pumping the whole flow of the sewer and assuming that no rain will occur while the river is high which would overload it. Such rains might occur rarely during the summer and might discharge for a few minutes with the sewer operating under pressure or through floodgates, but it is not believed that there is any possibility of their occurring during the spring freshet season or during high summer floods. The total amount of water which would reach the pumping stations under these conditions, would be 150 cubic feet per second, or 67,500 gallons per minute. The power for handling this discharge must be available at very short notice, and for such service steam engines and boilers are not entirely satisfactory. Steam would have to be raised at every sign of flood and the fires kept banked until all danger was over. Getting ready to pump with a steam outfit would often be more expensive than pumping, and the cost of the whole installation would be excessive.

Estimates have been made on the equipment and cost of a plant of a sufficient capacity using steam, producer gas, illuminating gas, and electricity as the motive power; and while the combination of electricity with a gas engine for break-down service has some advantages, yet it is believed that a station equipped with a sufficient number of alternating current electric motors and centrifugal pumps will be the cheapest and best plant. Electricity could be drawn from the power station at Dutch Point, the storage battery at State street and from either of the two hydro-electric stations on the Farmington River, so that a constant supply of power seems assured. Gas engines seem to be about the only other alternative. They are now furnished in fairly satisfactory forms and might possibly be used if there is any difficulty in making an advantageous agreement for the use of electric power. Gas engines, however, require more skilled attention than alternating electric motors, and are subject to many more troubles which might result in a break-down at a critical time.

ESTIMATED COST OF PUMPING STATION AT COMMERCE AND POTTER STREETS.

It would probably be advisable to install four 24-inch centrifugal pumps driven by 100 h. p. motors, with two 8-inch pumps to handle the dry weather flood. The equipment for such a station would cost:

For the four pumps and motors,	$19,000
Installation, wiring, etc.,	2,500
Piping, valves, etc.,	4,000
Foundations, building, etc.,	9,500
	$35,000

The cost of operation can only be approximately determined, because of the difficulty of forecasting average conditions. Assuming that for 25 days in the year for 24 hours

each day an average of 2,800 gallons of sewage per minute must be raised 10 feet, the consumption of electrical energy would be 3,700 kw. hours. At 4 cents per kw. hour the cost would amount to $148. If a heavy storm made it necessary to pump 16,200 gallons per minute against a 10-foot head for 48 hours, the consumption would be 3,260 kw. hours and at the same rate would cost $130.40. It is probable that the annual cost based on 25 days' total operation and including lubricants and repairs would not exceed $600 per annum. The annual cost might be roughly estimated as follows:

Cost of power,	$600.00
Cost of attendance,	62.50
	$662.50

METHOD OF DETERMINING NUMBER OF DAYS FOR OPERATION OF PUMPS.

The assumption that the pumps would have to be operated for 25 days each year seems conservative, as the city pumps for the Colt meadow district have been operated during the past ten years on an average of but 20.3 days each year. The maximum number of days was 26 in 1900 and 1901, and the minimum 12 in 1905.

The records kept by the Connecticut River Bridge and Highway District Commission show that for a period of 21 years from 1887 to 1907 inclusive, the water in the Connecticut River has been at or above elevation 16.6 (U. S. A. datum 15) for 339.2 days, or an average of 16.1 days for each year during this period. The highest number of days recorded was 31.8 in 1903. At no time during the years 1889 and 1894 did water in the Connecticut reach elevation 16.6. The two following tables give further details as to the number and distribution of days by months, when the Colt meadow pump was operated, and when the proposed pumps would have to be operated under similar river conditions. From the latter table it will be seen that from 1887 to 1907

inclusive, with one exception, that of December, 1888, all of the pumping would have occurred in the months of January, February, March, April, May and June. It does not follow, however, that it would be safe for the operator of the pumping plant to be absent for the latter six months in each year, but it does show that practically all freshets in the Connecticut River at Hartford, above elevation 16.6, occur in the first six months in each year.

Table showing number of days, 24 hours each, when City pump at Colt's Dock was operated. (Taken from bills of machinist in charge of engine, and not always accurate as regards dates.) Gates closed and pumps started when water in the Connecticut River reached elevation 14.0.

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total for Year.
1907	....	....	....	....	....	....	....	....	...	..	....	.....
1906	....	..	...	...	...	....	....	....	....	...	...	.....
1905	....	3.5	8.5	....	....	....	....	. ..	....	....	....	12.0
1904	....	4.0	6.5	4.0	....	...	....	....	....	....	....	14.5
1903	....	23.0	....	....	2.0	....	....	....	....	....	....	25.0
1902	....	15 0	6.5	....	....	....	....	....	....	..	....	21.5
1901	....	....	21.0	2.0	...	....	....	....	....	..	3.0	26.0
1900	4.	2.5	12.5	7.0	....	....	....	....	....	...	....	26.0
1899	...	....	16.0	6.5	....	....	....	....	...	....	....	22.5
1898	....	....	13.5	4.0	...	....	...	....	.	....	...	17.5
1897	....	...	7.0	....	4.0	6.5	1.5	....	..	...	4.0	23.0
1896	....	6.0	9.5	....	....	....	....	....	....	....	....	15.5

Total number of days for ten-year period,..... 203.5

Average number of days per year,..... 20.3

Table showing number of days in each month when river has stood at or above elevation 16.6 (U. S. A. elevation 15.) (Taken from wall chart in office of Bridge Commissioners.)

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Tota l.
1907	....	....	1.8	6.0	3.5	....	....	....	....	....	....	....	11.3
1906	....	....	....	...	11.7	....	....	....	....	...	....	....	11.7
1905	....	....	....	13.5	....	....	....	....	...	....	....	....	13.5
1904	....	....	....	16.2	4.5	....	....	..	....	....	....	....	20.7
1903	1.4	....	28.1	....	....	2.3	....	....	....	....	....	....	31.8
1902	4.5	....	21.5	5.2	....	....	....	..	....	....	....	....	31.2
1901	....	....	....	21.9	2.8	....	....	....	....	....	....	....	24.7
1900	....	....	2.8	1.5	12.2	....	....	....	....	....	....	....	16.5
1899	....	....	....	18.7	9.3	....	....	....	....	....	....	....	28.0
1898	4.7	....	....	....	22.2	....	....	...	....	....	....	...	26.9
1897	....	....	....	8.6	1.7	4.6	....	....	...	....	....	....	14.9
1896	1.7	0.8	7.5	12 3	....	....	....	....	....	....	....	....	22.3
1895	....	....	....	14.3	....	....	....	....	....	....	....	....	14.3
1894	....	....	....	....	....	....	....	....	....	....	....	....	0.0
1893	..	....	....	4.0	....	....	....	....	....	....	....	....	4.0
1892	....	....	....	7.1	....	....	....	...	....	....	....	....	7.1
1891	1.5	....	6.3	....	....	....	....	...	....	....	....	....	7.8
1890	....	....	....	5.5	....	....	....	....	....	....	....	....	5.5
1889	....	....	....	....	....	....	....	....	....	....	....	....	0.0
1888	....	....	....	3.0	12.0	....	....	....	....	...	....	5.0	20.0
1887	...	....	....	17.0	10.0	....	....	....	...	....	....	....	27.0

Total number of days for 21 years.....339.2
Average number of days per year... ..... 16.1

DAILY GAUGE HEIGHT
OF CONNECTICUT RIVER AT HARTFORD.

Showing Maximum, Average, and Minimum Heights at noon of each day from February 8, 1896, to December 31, 1907, inclusive, referred to Hartford City Datum.

Day.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1	14.2	13.3	19.2	25.5	20.8	17.2	7.4	18.8	6.8	10.5	17.1	10.5
	7.6	7.1	8.5	14.7	14.2	8.8	5.3	5.7	4.2	5.4	6.8	6.3
	4.6	4.5	3.7	8.1	6.8	3.5	3.8	2.9	2.8	2.4	4.3	4.1
2	12.0	12.4	2.1	25.7	19.7	13.0	6.9	14.6	6.1	9.6	14.1	9.1
	7.4	7.2	10.0	14 8	13.8	8.8	5.4	5.5	4 2	5.4	6.4	6.1
	4.6	4 4	4.0	8.2	6.5	4.1	3.3	2.7	2.6	1.9	3.9	4.1
3	10.7	12.9	27.7	23.8	19.2	12.0	8.2	11.5	6.4	8.8	13.5	8.7
	7.1	6.8	11.1	14.4	13.2	7.6	5.6	5.3	4 3	5.3	6.3	6.0
	4.6	4.1	3.9	9 2	6.5	4.1	3.3	2.8	3.0	2.2	4.1	4.2
4	9.2	12.5	27.1	21.1	19.1	10.8	8.2	9.8	9.8	8.5	17.6	10.6
	7.0	6.8	11.2	13.8	12.9	7.2	5.3	5 1	4.8	5.2	6.8	6.2
	4.6	3.9	3.6	9.3	6.7	4.1	3.4	3.6	3.1	3.0	3.2	3.3
5	10 3	12.6	26 8	18.7	18.0	9 9	8.1	9.7	12.4	8.6	17.6	12.7
	7.3	7.0	10.4	13.0	12.5	6.9	5.5	5.1	5.0	5.2	6.9	6.5
	4.6	4.0	4.1	9.4	6.7	4.1	3.5	3.3	3.2	3.5	3.7	3.6
6	11.3	12.2	23.3	17.5	17 2	9.4	8.1	9.3	15.1	8.8	16.2	11.2
	7.5	7.1	9.9	13.0	11.7	6.9	5.6	5.2	5.2	5.2	6.8	6.7
	4.3	3.8	3.5	9.8	6.6	4.2	3.5	3.1	3.4	3.3	4.0	3.4
7	12.8	13.0	18.4	21.2	16.3	9.8	7.4	8.8	13.0	8.2	18.3	11.1
	7.5	7.0	9.2	13.3	11.2	6.8	5.5	5.2	5.0	5.4	6.9	6.5
	4.1	4.8	4.3	10.0	6.5	3.7	3.5	3.2	3.3	3.0	3.9	3.3
8	12.2	13.7	15.4	25 0	15.8	9.9	7.0	8.0	10.8	8.5	22.3	10.8
	7.9	7.3	9 3	14.0	10.5	7.0	5.2	5.0	4.8	5.1	7.1	6.3
	3.8	4.4	4.5	9.7	6.3	3.5	3.5	2.9	3.6	2.4	2.7	4.1
9	13.3	13.7	16.0	28 1	15.2	8.6	6.1	6.9	9.1	10.1	22.2	9.9
	7.5	7.5	9.6	14.5	9.9	6.8	5.0	4.9	4.6	5.1	7.2	6.1
	4.0	4.6	4.7	8.8	6 0	3.8	3.3	3.1	2.7	3.2	3.4	4.0
10	11.5	12.8	19.8	27.0	14.6	13.4	7.0	7.0	7.6	11.1	19.7	9.3
	7.7	7.3	10.0	15.5	9.4	7.3	5.2	4.6	4.4	5 4	6.6	6.3
	4.3	4 0	4.6	8.7	5.7	3.6	3.4	3.2	1.7	3.3	2.8	4.4
11	10 3	11.8	21.4	25.2	14.6	19.0	6.3	6.6	6.8	10.7	16.2	10.8
	7.4	7.0	9.8	15.5	9.3	7.7	4.7	4.8	4.4	5.4	6.6	6.6
	4.9	3.4	4.0	9.0	5.5	3.6	3.6	3.8	2.1	2 9	1.9	3.9
12	10.8	10.4	23.3	22.4	14.6	21.9	5.8	8.8	6.7	10.3	14.7	15.5
	7.7	7.0	10.1	15.1	9.2	7.7	4.7	4.9	4.4	5.4	7.2	6.8
	5.2	4.5	5.2	9.4	5.6	4.1	3.6	3.3	2.6	3.5	4.0	3.2
13	10.4	12.3	24.4	21.2	14.3	20.0	6.2	9.4	7.1	10.1	13.2	16.4
	7.2	7.3	10.4	14.7	9.1	7.0	4.6	4.9	4.5	5.5	6.9	7.2
	4.8	4.5	5.1	9 8	5.3	4.0	3.6	3.2	3.2	3.6	3.8	5.0
14	10.3	22.8	24.0	19.2	14.1	17.4	12.2	8.4	7.9	10.2	11.4	15.4
	7.2	8.0	11.0	14.3	9.2	7.4	4.8	4.7	4.5	5.6	6.6	7.2
	4.5	4.5	5.1	9.7	5.3	3.9	3.2	3.0	3.2	3.5	4.0	4.4
15	10.6	24.5	22.8	19.6	16.1	15.0	19.8	7.6	7.3	9.7	10.3	15.9
	7.1	8.1	11.1	14.2	9.2	7.1	4 3	4.6	4.5	6.0	6.5	7.6
	4.3	4.5	5.6	9.8	5.2	3.8	3.2	2.8	3.2	3.8	4.1	4.4

DAILY GAUGE HEIGHT
OF CONNECTICUT RIVER AT HARTFORD.

(Continued from page 64.)

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
16	10.9	23.2	22.2	21.2	15.9	18.2	22.0	6.8	10.5	10.2	9.6	21.3
	7.1	7.9	10.7	14.4	9.1	6.9	5.5	4.6	5.5	6.2	6.0	8.6
	4.3	4.6	5.3	10.3	5.1	3.8	3.0	3.3	3.2	3.9	4.2	4.4
17	10.9	20.8	21.2	22.5	15.2	13.3	21.2	7.9	9.8	9.0	8.7	21.5
	6.9	7.3	10.4	14.9	8.9	6.7	5.5	4.8	5.3	5.9	5.9	8.6
	4.1	4.2	5.1	10.7	4.7	4.2	2.9	3.0	3.2	3.8	3.9	3.8
18	11.2	15.8	21.0	22.0	13.3	10.8	19.7	8.0	9.7	8.0	8.4	20.1
	6.9	6.7	10.3	15.3	9.0	6.3	5.2	4.8	5.0	5.6	5.9	8.7
	4.1	4.1	5.3	10.3	4.7	4.2	2.8	2.9	2.1	3.6	3.2	4.0
19	10.7	12.6	21.7	23.2	14.6	9.2	18.4	7.2	6.8	7.1	11.4	17.4
	6.8	6.9	10.3	15.1	9.2	6.0	5.3	4.6	4.9	5.4	6.0	8.4
	4.1	3.9	5.4	9.8	4.6	4.0	2.8	2.8	2.1	3.7	3.7	4.0
20	9.7	12.5	19.9	23.4	14.6	9.0	15.6	7.2	12.2	6.9	12.4	14.9
	6.5	6.8	11.2	14.9	9.7	6.0	5.1	4.8	5.1	5.2	6.3	7.8
	4.1	3.1	5.2	9.6	4.7	4.2	1.8	2.4	2.1	3.3	4.2	4.3
21	9.4	13.2	20.3	23.4	20.5	8.6	12.1	6.7	12.2	7.7	13.5	13.9
	7.1	7.0	11.1	14.8	10.2	6.0	4.8	4.8	5.0	5.4	6.3	7.4
	5.1	4.3	4.3	9.1	4.4	4.2	2.3	2.7	2.5	3.4	4.3	4.2
22	11.5	13.2	22.2	24.0	16.0	18.0	10.2	6.2	11.6	8.4	12.9	14.8
	7.5	7.2	12.0	14.09	9.5	6.6	5.1	4.6	4.8	6.0	6.2	7.5
	5.1	4.5	5.4	8.4	4.6	3.3	2.9	2.7	2.7	3.7	4.4	3.8
23	13.7	13.0	21.7	24.02	15.0	18 4	13.2	6.5	10.9	10.0	12.0	16.4
	8.2	7.8	11 7	15.0	9.0	6.7	5.4	4.5	4.8	6.3	6.2	7.6
	5.1	4.4	4.8	8.2	4.2	3.6	3.4	2.7	2.5	3.8	4.3	3.8
24	14.3	12.4	23.4	23.6	14.2	15.4	13.8	6.4	9.4	9.2	10.8	16.3
	8.2	7.8	11.9	14.4	8.5	6.7	5.5	4.4	4.9	6.1	6.3	7.6
	4.8	4.1	4.1	8.4	3.9	3.7	3.3	2.8	2.7	4.0	5.0	4.1
25	15.3	11.9	25.0	22.7	13.4	12.6	13.8	6.0	8.1	8.2	10.0	14.2
	8.6	7.5	12.3	14.5	8.1	6.0	5.3	4.5	5.1	6.2	6.2	7.3
	4.5	3.1	3.4	8.0	4.1	3.3	3.1	2.9	2.8	4.2	4.2	3.6
26	15.7	12.2	24.8	23.4	13.5	10.8	12.5	7.2	7.2	7.9	9.7	12.3
	8.2	7.3	12.5	14.7	7.8	5.7	5.4	4.7	5.1	5.8	6.2	7.1
	3.9	4.1	4.0	7.5	4.2	3.6	3.6	2.9	2.9	4.0	3.7	3.2
27	13.8	12.2	22.8	22.7	14.0	9.7	11.4	7.2	7.5	8.3	12.2	11.4
	7.8	7.6	13.4	14.5	7.8	5.5	5.1	4.7	5.1	5.8	6.2	7.2
	3.9	3.8	4.9	7.5	3.8	2.9	3.4	2.8	2.6	4.2	3.8	4.4
28	12.2	15.6	21.0	23.1	14.9	8.4	13.2	6.3	7.8	11.0	11.2	10.2
	7.5	7.8	14.0	14.8	8.3	5.3	5.2	4.5	5.0	5.9	6.2	7.2
	4.0	4 0	6.3	7.3	3.8	3.7	3.2	2.7	3.0	4.2	3.5	4.8
29	13.9	17.2	21.8	22.2	15.4	7.4	13.6	6.8	7.4	12.7	12.3	9.9
	7.6	8.1	14.4	14.5	9.3	5.1	5.1	4.5	5.2	6.7	6.6	7.1
	4.1	3.9	7.8	7.1	3.8	4.1	3.0	2.7	3.2	3.9	4.4	4.7
30	14.6		22.4	22.0	16.0	7.4	20.4	6.9	8.8	18.6	11.4	13.6
	7.4		14.6	14.4	9.6	5.2	5.6	4.5	5.3	7.5	6.6	7.5
	4.7		7.8	7.0	4.1	3.4	2.5	2.7	2.8	4.0	4.3	4.2
31	14.1		24.2		16.0		21.8	7.0		19.3		16.2
	7.2		14.7		9.4		5.8	4.5		7.2		7.7
	4.8		8.0		3.5		2.7	2.8		4.3		4.4

It appears then that it is perfectly feasible to dyke the whole of the flooded district, and there is no doubt but that the first cost under the dyke plan would be less than that of any other plan. There are reasons, however, for believing that the ultimate benefit of raising the whole inundated area above flood height would be very great. The idea of having the whole of the low area of the east side of the city dependent for safety upon the reliability of a set of pumps may have a deterrent influence in the uses of property within the dyke. In fact the idea of safety is the one greatest benefit to be secured. Without it the improvement will never produce proper increases in land values. Without it the district will remain much as it is today. With the knowledge that the water in the Connecticut River stands higher than their heads outside a bank of dirt ready to rush in through some unknown drain that may burst open under the great pressure, can the people be given this assurance of absolute safety? The pumps can be duplicated beyond the human probability of failure; the dyke can be made as water-tight as desired, and there would be no more reason to fear damage from freshets in the First and Second Wards than from earthquakes in the Eighth; but would everyone believe this? Would not many still be fearful when the river is high, and when large enterprises were seeking new locations, would not the decision be turned against the East Side by the old bugbear of the freshets?

RAISING THE ENTIRE INUNDATED DISTRICT.

Believing that there is a good deal of truth in the above theory, much more time and energy has been expended upon a detailed study of raising the entire flooded area than upon any other part of the east side problem, because I am convinced that while it may not be best to attempt to carry out this plan at present, owing to financial reasons, I do believe that this will be the ultimate solution of this problem.

VIEW OF LOWER STATE STREET DURING FRESHET IN THE CONNECTICUT RIVER. LOOKING EASTERLY FROM NEAR FRONT STREET.

This flooding nuisance eliminated by change in grade of State street and the construction of Connecticut Boulevard by the Connecticut River Bridge and Highway District Commission. All buildings on left of View destroyed for the location of Connecticut Boulevard.

and therefore every dollar expended from now on should be spent with this end in view.

In the earlier investigations, the committee of 1866, consisting of N. H. Morgan, Frank W. Cheney, and Jonathan B. Bunce, strongly recommended the raising of the entire flooded area. In 1867 General William B. Franklin also favored this plan. Obviously the only sure method of preventing the buildings within the afflicted district from being damaged by freshets, is to lift them bodily above the danger line.

If the raising plan were to be adopted, one of the first considerations would be a decision as to the elevation of the new grade to be safely above freshet level. Upon this question there was quite a difference of opinion among the earlier investigators, as there undoubtedly would be at the present time.

General Ellis, an eminent engineer, favored 33.4 for the height of the proposed dyke, the same as that of Colt's dyke, and two feet above the 1854 freshet (31.4). The 1866 committee, Engineer James Laurie, and General William B. Franklin, favored 34.4, three feet above the high water mark of 1854, for the crest of the proposed dyke. In 1896 the council committee of Mayor Miles B. Preston recommended a height of 32.4, or one foot above the 1854 freshet.

The lowest street in the district today is at elevation 24.2, so that the maximum fill to elevation 32.0 which is considered safe, would be only 7.8 feet. Front street from State street northerly to Morgan street would require raising from 6.2 feet at Talcott street to 1.4 feet at State street. Having in mind the fact that the grade of the new freight yard north of Morgan street, as well as that of the intersection of Front and State streets is about 30.5, or approximately ten inches below the 1854 freshet, estimates have been made of the cost of raising the entire flooded area to this grade, and also to elevation 32, so that by interpolation, the approximate cost of raising this district to any other

grade near these elevations can be readily determined. Before starting this part of the investigation, Mr. Brazel, the responsible building mover, furnished estimates of the cost of raising three or four representative buildings in the district, and his estimates were used as unit prices in determining the probable cost of raising all the buildings throughout the district which now are below the danger line. Careful levels were taken of the ground surface over the entire area, the elevation of the cellar and first floor of each building being noted. Estimates were then prepared of the cost of removing and replacing the curbing and sidewalks upon each street, of filling in the highways, yards and cellars to the assumed elevations, of raising all buildings and preparing new foundations for the same, and of repaving all of the streets so disturbed, with macadam and granite paving.

The following tables show in detail the results of these calculations:

ESTIMATED COST OF RAISING THE COMMERCE STREET SECTION FROM PARK RIVER TO STATE STREET, TO ELEVATION 30.5.

STREET	CURB		WALK		HIGHWAY					YARDS		BUILDINGS			CELLARS			TOTAL COST	
	Length Feet	Cost	Area, Sq. ft.	Cost	Area, Sq. yd.	Macadam Cost	Granite, Cost	Fill. Cu. yd.	Cost	Fill. Cu. yds.	Cost	Total No.	Affected	Cost Raise	Fill. Cu. yd.	Cost	Assessed Valuation	Macadam	Granite
Grove, ...	1,112	$1,112	6,672	$1,000	1,618	$1,618	$3,640	4,514	$3,386	8,232	$6,174	13	13	$7,325	4,488	$3,366	$61,200	$23,981	$26,003
Keeney, ...	.....	.....	.....	.....	1,031	1,031	2,320	2,626	1,970	.....	.....	....	...	.....	.....	.....	.....	3,001	4,290
Potter, ...	1,458	1,458	10,206	1,531	2,860	2,860	6,435	8,778	6,584	14,500	10,875	24	18	11,345	2,150	1,613	21,800	36,266	39,841
Arch.	506	506	3,036	455	762	762	1,715	426	320	886	665	9	1	350	.....	.....	37,200	2,708	3,661
Front, ...	1,314	1,314	13,140	1,971	3,825	3,825	8,606	3,821	2,866	10,212	7,659	47	17	10,850	658	494	179,800	29,329	34,109
Mechanic,	1,251	1,251	12,510	1,877	2,050	2,050	4,613	6,030	4,523	7,434	5,576	15	15	15,725	1,235	926	45,800	31,928	34,491
Commerce,	2,661	2,661	18,627	2,794	4,464	4,464	10,044	12,589	9,442	39,155	29,366	32	21	26,281	2,260	1,695	125,700	76,703	82,283
Ellery, ...	712	712	4,984	748	739	739	1,663	3,157	2,368	11,570	8,678	8	7	5 820	880	660	10,700	19,725	20,649
	9,014	$9,014	69,175	$10,376	17,349	$17,349	$39,036	41,941	$31,459	91,989	$68,993	148	92	$77.696	11,671	$8,754	$482,200	$223,641	$245.327

ESTIMATED COST OF RAISING THE COMMERCE STREET SECTION, FROM PARK RIVER TO STATE STREET, TO ELEVATION 32.0

STREET	CURB		WALK		HIGHWAY					YARDS		BUILDINGS			CELLARS TO 24.5		Assessed Valuation	TOTAL COST	
	Length, Feet	Cost	Area, Sq. ft.	Cost	Area, Sq. yds.	Macadam, Cost	Granite, Cost	Fill, Cu. yds.	Cost	Fill, Cu. yds.	Cost	Total No.	Affected	Cost to Raise	Fill, Cu. yds.	Cost		Macadam	Granite
Grove,....	1,187	$1,187	7,122	$1,068	1,702	$1,702	$3,880	5,765	$4,324	11,081	$8,311	13	13	$7,325	5,777	$4,333	$61,200	$28,250	$30,378
Keney,....	.....	.....	.....	.....	1,031	1,031	2,320	3,142	2,357	.....	.....	...	...	.....	.....	.....	.....	3,388	4,677
Potter, ...	1,458	1,458	10,206	1,531	2,860	2,860	6,435	10,978	8,234	19,409	14,557	24	18	11,345	3,175	2,381	21,800	42,366	45,941
Arch,.....	816	816	4,896	734	1,251	1,251	2,815	1,327	996	2,222	1,667	9	2	1,115	.....	.....	37,200	6,579	8,148
Front, ...	1,314	1,314	13,140	1,971	3,825	3,825	8,606	7,022	5,267	16,790	12,593	47	24	13,915	1,549	1,162	179,800	40,047	44,827
Mechanic,.	1,251	1,251	12,510	1,877	2,050	2,050	4,613	7,738	5,804	1,000	750	15	15	15,725	2,275	1,706	45,800	29,168	31,726
Commerce,	2,661	2,661	18,627	2,794	4,464	4,464	10,044	15,868	11,901	49,209	36,907	32	21	26,281	2,915	2,186	125,700	87,194	92,774
Ellery,....	712	712	4,984	748	739	739	1,663	3,799	2,849	14,916	11,187	8	7	5,820	1,500	1,125	10,700	23,180	24,104
	9,399	$9,399	71,485	$10,723	17,922	$17,922	$40,326	55,639	$41,732	114,627	$85,972	148	100	$81,525	17,191	12,893	$482,200	$260,167	$282,570

ESTIMATED COST OF RAISING THE BOULEVARD SECTION, FROM STATE STREET TO MORGAN STREET, TO ELEVATION 30.5.

STREET	CURB		WALK		HIGHWAY					YARDS		BUILDING			CELLARS TO 23.0		Assessed Valuation	TOTAL COST	
	Length Feet	Cost	Area Sq. Ft.	Cost	Area Sq. Yds.	Macadam Cost	Granite Cost	Fill. Cu. yds.	Cost	Fill. Cu. yds.	Cost	Total No.	Affected	Cost Raise	Fill. Cu. yds.	Cost		Macadam	Granite
State,	1,134	$1,134	13,608	$2,041	2,939	$2,939	$6,613	7,582	$5,687	4,042	$3,032	23	21	$45,175	4,850	$3,640	$176,500	63,648	$67,322
Ferry,	985	985	8,865	1,330	1,347	1,347	3,031	3,614	2,711	3,132	2,349	28	28	17,387	2,326	1,745	49,700	27,854	29,538
Kilbourn,	802	802	8,020	1,203	1,333	1,333	2,999	3,339	2,504	5,133	3,850	10	10	13,800	1,995	1,496	42,900	24,988	26,654
Temple,	50	50	400	60	96	96	216	17	13									219	339
Morgan,																			
Talcott,	1,007	1,007	8,560	1,284	1,206	1,206	2,714	2,339	1,754	390	293	13	4	4,282	709	532	19,000	10,358	11,866
Front,	2,626	2,626	32,825	4,924	3,867	3,867	8,701	6,401	4,801	7,252	5,439	93	75	41,525	2,418	1,814	271,560	64,996	69,830
Charles,	1,860	1,860	11,160	1,674	1,910	1,910	4,298	5,257	3,943	6,057	4,543	45	34	17,915	1,804	1,353	54,900	33,198	35,586
	8,464	$8,464	83,438	$12,516	12,698	$12,698	$28,572	28,549	$21,413	26,006	$19,506	212	172	$140,084	14,102	$10,580	$614,560	225,261	$241,135

ESTIMATED COST OF RAISING THE BOULEVARD SECTION, FROM STATE STREET TO MORGAN STREET, TO ELEVATION 32 0.

STREET	CURB		WALK		HIGHWAY					YARDS		BUILDINGS			CELLARS 24.5.			TOTAL COST	
	Length Feet	Cost	Area Sq. Ft.	Cost	Area Sq. yds.	Macadam Cost	Granite Cost	Fill, Cu. yds.	Cost	Fill, Cu. yds.	Cost	Total No.	Affected	Cost Raise	Fill Cu. yds.	Cost	Assessed Valuation	Macadam	Granite
State, ...	1,134	$1,134	13,608	2,041	2,939	$2,939	$6,613	9,815	$7,360	5,492	$4,119	23	21	$45,175	7,030	$5,273	$176,500	$68,041	$71,715
Ferry, ...	985	985	8,865	1,330	1,347	1,347	3,031	4,809	3,607	4,223	3,167	28	28	17,387	3,734	2,801	49,700	30,624	32,308
Kilbourn,	802	802	8,020	1,203	1,333	1,333	2,999	4,300	3,225	6,579	4,934	10	10	13,800	3,242	2,432	42,900	27,729	29,395
Temple, ...	161	161	1,288	193	366	366	824	171	128									848	1,306
Morgan,. ..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	..	..	.....	.....	.....	.....	.....	.....
Talcott,....	1,157	1,157	9,834	1,475	1,398	1,398	3,146	3,368	2,526	1,097	823	13	4	4,282	1,087	815	19,000	12,476	14 224
Front, ...	2,626	2,626	32,825	4,924	3,867	3,867	8,701	10,268	7,701	11,568	8,676	93	81	45,775	5,069	3,802	271,560	77,371	82,205
Charles, ...	1,860	1,860	11,160	1,674	1,910	1,910	4,298	6,851	5,138	8,147	5,285	31	27	17,915	3,037	2,278	54,900	36,060	38,448
	8,725	$8,725	85,600	12,840	13,160	13,160	$29,612	39,580	$29,685	36,006	$27,004	198	171	$144,334	23,199	$17,401	$614,560	$253,149	$269,601

ESTIMATED COST OF RAISING THE WINDSOR STREET SECTION, FROM MORGAN STREET TO THE N. Y., N. H. & H. R. R., TO ELEVATION 30.5

STREET	CURB		WALK		HIGHWAY					YARDS		BUILDINGS			CELLARS TO 23.0		Assessed Valuation	TOTAL COST	
	Length, Feet	Cost	Area, Sq. ft.	Cost	Area, Sq. yds.	Macadam, Cost	Granite, Cost	Fill, Cu. yds.	Cost	Fill, Cu. yds.	Cost	Total No.	Affected	Cost, Raise	Fill, Cu. yds.	Cost		Macadam	Granite
Portland, .	1,388	$1,388	9,716	$1,457	2,005	$2,005	$4,511	2,908	$2,181	3,832	$2,875	34	8	$1,839	54	$41	$88,400	$11,786	$14,292
Windsor, .	2,186	2,186	30,004	4,500	4,129	4,129	9,290	7,257	5,443	11,520	8,640	57	25	10,309	712	534	220,600	35,741	40,902
Village,...	60	60	600	90	100	100	225	1,507	1,130	4,262	3,200	22	18	4,020	287	215	26,800	8,815	8,940
Market,...	1,546	1,546	12,368	1,855	2,062	2,062	4,640	4,568	3,426	17,883	13,410	48	36	15,665	595	446	133,400	38,410	40,988
No. Front,	1,032	1,032	7,740	1,161	3,084	3,084	6,939	8,393	6,294	16,200	12,150	26	21	3,663	48	36	6,900	27,420	31,275
Pleasant,..	1,134	1,134	8,505	1,276	1,575	1,575	3,544	2,214	1,662	7,853	5,890	38	26	6,464	102	77	96,600	18,078	20,047
North,....	1,404	1,404	8,424	1,264	2,184	2,184	4,914	3,382	2,537	8,562	6,420	31	25	9,226	605	454	66,000	23,489	26,219
Pequot,...	946	946	7,095	1,064	1,314	1,314	2,957	2,684	2,013	7,606	5,705	11	4	1,354	123	92	39,500	12,488	14,131
Avon, ...	1,122	1,122	7,854	1,178	1,558	1,558	3,506	3,972	2,979	6,470	4,855	32	25	5,630	511	383	69,200	17,705	19,653
	10,818	$10,818	92,306	$13,845	18,011	$18,011	$40,526	36,885	$27,665	84,188	$63,145	299	188	$58,170	3,037	$2,278	$747,400	$193,932	$216,447

ESTIMATED COST OF RAISING THE WINDSOR STREET SECTION, FROM MORGAN STREET TO THE N. Y., N. H. & H. R. R., TO ELEVATION 32.0.

STREET	CURB		WALK		HIGHWAY					YARDS		BUILDINGS			CELLARS TO 24.5		Assessed Valuation	TOTAL COST	
	Length, Feet	Cost	Area, Sq. ft.	Cost	Area, Sq. yds.	Macadam, Cost	Granite, Cost	Fill, Cu. yds.	Cost	Fill, Cu. yds.	Cost	Total No.	Affected	Cost, Raise	Fill, Cu. yd.	Cost		Macadam	Granite
Portland, .	1,490	$1,490	10,430	$1,565	2,152	$2,152	$4,842	4,506	$3,380	7,971	$5,980	34	12	$3,841	266	$200	$88,400	$18,608	$21,298
Windsor, .	2,438	2,438	34,132	5,120	4,605	4,605	10,361	112,981	8,474	27,703	20,777	57	40	18,901	2,073	1,555	220,600	61,870	67,626
Village,...	300	300	3,000	450	524	524	1,179	2,828	2,121	5,976	4,480	22	19	4,896	505	379	26,800	13,150	13,805
Market,...	1,632	1,632	13,056	1,958	2,176	2,176	4,896	6,407	4,806	27,439	20,579	48	43	22,665	2,484	1,863	133,400	55,679	58,399
No. Front,	1,032	1,032	7,740	1,161	3,084	3,084	6,939	10,862	8,145	21,090	15,815	26	15	4,633	193	145	6,900	34,015	37,870
Pleasant,..	1,270	1,270	9,525	1,429	1,764	1,764	3,969	3,716	2,787	12,822	9,615	38	29	9,532	554	416	96,600	26,813	29,018
North,....	1,404	1,404	8,424	1,264	2,184	2,184	4,914	4,987	3,740	12,007	9,005	31	31	13,675	1,784	1,338	66,000	32,610	35,340
Pequot,...	946	946	7,095	1,064	1,314	1,314	2,957	3,733	2,800	10,759	8,069	11	10	6,110	239	179	39,500	20,482	22,125
Avon, ...	1,200	1,200	8,400	1,260	1,733	1,733	3,899	5,261	3,946	9,248	6,935	32	28	7,863	1,305	979	69,200	23,917	26,082
	11,712	$11,712	101,802	$15,271	19,536	$19,536	$43,956	155,281	$40,199	135,015	$101,255	299	227	$92,116	9,403	$7,054	$747,400	$287,144	$311,563

VIEW OF MARKET STREET DURING FRESHET IN THE CONNECTICUT RIVER. LOOKING NORTHERLY FROM MORGAN STREET.

Grouping the above figures for each district we find the estimated cost of raising the entire inundated area to different elevations to be as follows:

For Elevation 30.5 (10 inches Below 1854 Freshet).

District.	Assessed valuation.	Cost if Sts. are macadamized.	Cost if Sts. are paved with granite.
Commerce St.,	$482,200	$223,641	$245,327
Boulevard,	614,560	225,261	241,135
Windsor St.,	747,400	193,932	216,447
Total,	$1,844,160	$642,834	$702,909

For Elevation 32.0.

Commerce St.,	$482,200	$260,167	$282,570
Boulevard,	614,560	253,149	269,601
Windsor St.,	747,400	287,144	311,563
Total,	$1,844,160	$800,460	$863,734

For Elevation 33.5 (By Interpolation).

Total,	$1,844,160	$958,086	$1,024,559

For Elevation 34.5 (By Interpolation).

Total,	$1,844,160	$1,063,169	$1,131,775

In the sixties, Engineer James Laurie estimated the cost of raising the entire area to elevation 32.4 as follows:

District S. of Morgan St. and above Commerce St., 425,000 cu. yds.

District N. of Morgan St. and above Front St., 700,000 cu. yds.

Total 1,125,000 cubic yards at 40 cents = $450,000.

Mr. Laurie's estimate did not provide for raising the streets in these two districts which he figured would add $137,500, making a total of $587,500.

While the estimated cost of raising the inundated district in the sixties appeared like a vast undertaking, the cost today would be much greater on account of the additional amount of curbing, sidewalks, paving, etc., to be removed and restored, and the larger number of buildings to be raised. If the raising plan were to be adopted, the sewerage system for the east side would naturally be somewhat different from that previously outlined in this report. The surface water from the yards and streets could then be discharged directly into the Connecticut River at all times without pumping. If the present sewers were used for such purposes, new sewers would have to be built in all of the streets, to prevent cellar flooding and to collect the sewage, and an interceptor would be required to carry the sewage to a central pumping station; otherwise the river front would remain as polluted as at present. The only practical difference in the two sewerage systems would be the excess size and cost of the river front interceptor nesessary to carry the amount of surface water from the entire district, and the slight additional expense of pumping this surface water, for a few days each year, while the gates were closed during freshets in the Connecticut River, less the cost of providing a double system of sewers back from the river to an elevation above freshet level, in each street where flooding now occurs.

An interceptor of some kind must be built inside of the proposed dyke to carry the flow of the present sewers to the pumping station at Commerce and Potter streets, and if it is to carry sewage and surface water from the whole area, from one year's end to another, it must be larger than if it carries only sewage. Every sewer crossed would be connected, and new local sewers, with sewage flowing westerly into the trunk sewer, instead of easterly into the Connecticut River as at present, would be built in the easterly portion of streets north of Morgan street.

I believe the river front interceptor and pumping stations previously described, can be constructed for about

$200,000.00. This work could very properly be spread over a period of three years, but in my opinion it should not be divided into more than three sections. It would be much more economical to let the work in one contract with the understanding that it should be completed within three years.

After the completion of this work, Commerce street should be raised, and possibly widened, from State street to, or across Park River. This, with slight changes in Potter, Front, and Arch streets, and the work north of State street, would completely dyke all of the east side, between Park River and the N. Y., N. H. & H. R. R., and prevent cellar and surface flooding from freshets in the Connecticut River.

If the dyking is not continued south of State street, the Grove street sewer could be connected with the river front interceptor, and flooding up to elevation 23.0 would thus be prevented in the Commerce street section, but the connection would have to be made so that it could be closed when water in the Connecticut River rose above the surface of Commerce and Grove streets, and above that elevation there would be no protection.

EXTENSION OF RIVER FRONT INTERCEPTOR.

As previously stated in this report, the river front interceptor should eventually be extended to a new outlet further down the river, or to filtration beds in the South Meadows, or to some other favorable location below the city. This extension may be delayed for many years, but my impression is that there will be a growing demand for its construction soon after the interceptor is completed north of Park River. The Colt Meadow section should be designed to carry the sewage from the Park River Valley interceptor, as well as that of the river front interceptor north of Park River.

While no extensive detailed study has been made of the location and sizes of this extension, it has been considered

in a general way as a part of the problem north of Park River. There appear to be several routes available for the location of this interceptor.

(1) From Potter street it could be continued southerly in Commerce street to and under Park River, thence through Taylor street, Charter Oak avenue, and Huyshope avenue, or from the corner of Commerce and Sheldon streets it could cut diagonally across private property to the corner of Charter Oak and Huyshope avenues, and then continue through the latter avenue. I would not advise the latter location even if shorter and cheaper, because public sewers built across private properties are perpetual encumbrances.

(2) Another route which would be much more economical to build upon, on account of the shallow cutting, but which would not produce as great local benefits, would be to commence at the corner of Potter and Commerce streets, thence easterly and southerly in Potter street to and under Park River, thence to continue outside of and parallel with Vandyke avenue or the Colt dyke, with sufficient covering only to properly protect the sewer from frost action. By following this route the Colt Meadow dyke would not be pierced or tunneled under, as it would be if location No. 1 were adopted. On the other hand by constructing this extension through Taylor street, Charter Oak avenue, and Huyshope avenue, even at a considerable additional expense, the local drainage facilities in these streets would be so greatly improved that the extra cost would be largely, if not wholly, compensated for by the improved sanitary condition of this section. As the volume of water in the Connecticut River even at low water is so large in comparison with the present discharge of sewage, this extension can undoubtedly be postponed for many years. When it is done, however, there may be other considerations which will influence the final decision as to the route most desirable, but I can see no physical difficulties at the present time to interfere with such an extension.

The outlet should be far enough south to avoid all pollution of Park River, Dutch Point and Colt Park, and it is probable that somewhere in the vicinity of such an outlet will be found the best possible location for sewage purification works.

IMPROVEMENT OF SEWERAGE FACILITIES IN THE COLT MEADOW DISTRICT.

No report upon the solution of the east side flooding problem would be complete without a discussion of the cellar flooding nuisance in the Colt Meadow district, due to the shallow, inadequate, and defective condition of several local sewers.

The sewage from the area within the Colt dyke is now handled, during high water stages in the Connecticut River, by two pumping stations. One is located at the corner of Commerce and Sheldon streets, and is operated by the city. This station pumps all of the sewage and surface water from the section between Wyllys street on the south and Park River on the north. The second pumping station is located in the building of, and is operated by the Colt Patent Fire Arms Company, and handles the drainage from the area south of Wyllys street and Charter Oak avenue.

1st. AREA BETWEEN SHELDON ST. AND WYLLYS ST.

The Charter Oak avenue sewer west of Governor street is 10-inch tile on a grade of 2.75 per cent., and will discharge 3.4 cubic feet per second. The Governor street sewer north of Charter Oak avenue is 10-inch tile on an 0.8 per cent. grade, and discharges 1.8 cubic feet per second. The Governor street sewer south of Charter Oak avenue is 18-inch brick on an 0.875 per cent. grade discharging 9.6 cubic feet per second; making a total discharge of 14.8 cubic feet per second to be carried by the Charter Oak avenue sewer east of Governor street, in addition to what may be added by catch basins and house drains locally, which will probably not exceed 10 cubic feet per second, or say 25 cubic feet total.

The diameter of this section is 24 inches and the rate 2 per cent., making a discharge of 32 cubic feet per second, which is ample to take care of the 25 cubic feet entering.

At Woodbridge street there enters a 15-inch tile on a 0.16 per cent. grade adding only 2.5 cubic feet per second, but the grade of the Charter Oak avenue sewer drops here from 2 per cent. to 0.325 per cent., which will carry only 12½ cubic feet per second, or about one-half the possible discharge. It will be necessary, therefore, to rebuild the sewer from Woodbridge street east. The run-off from this area (i. e. the 41 acres east of South Prospect street), figures about 50 cubic feet per second, and with a 0.5 per cent. grade requires a 36-inch sewer. If built before the Colt Meadow section of the river front interceptor, this sewer should start at elevation 7.0 at the present pumping station, and replace the existing Taylor street sewer at a lower elevation. Upon reaching Charter Oak avenue, the size can be reduced to 30-inch and continued to Woodbridge street of this diameter. At this grade (0.5 per cent.), the depth to the flow line at Union street would be 8 feet or 2½ feet deeper than the present sewer, and at Woodbridge street, 10 feet.

If the new local sewers in the Colt Meadow district are not built until after the river front interceptor has been completed through this section, the outlet should be through Charter Oak avenue to the interceptor at Huyshope avenue, or outside of the Vandyke avenue dyke.

In Union street south of Charter Oak avenue a line of 24-inch tile on a 0.3 per cent. grade should replace the existing 12-inch tile. This should enter Wyllys street and extend west as 18-inch for 340 feet at 0.3 per cent.; thence 285 feet at 3.6 per cent., to be 10-inch; thence 150 feet at 7 per cent. to be 10-inch. This would carry it to within 50 feet of Governor street, and it could be continued to Main street if necessary. Provision should also be made for a future extension easterly in Wyllys street to Charter Oak avenue.

If it should be deemed advisable to secure greater depth

of flow line at the low point opposite Union street in Charter Oak avenue, an egg shaped sewer 3 feet x 4 feet 6 inches would carry the same discharge through Taylor street on a 0.2 per cent. grade, and at Charter Oak avenue the size could be reduced to 2 feet 6 inches x 3 feet 9 inches. This would help materially in Union street south of Charter Oak avenue and in the lower part of Wyllys street, by keeping the flow line at a greater depth below the street level. At the corner of Union street and Charter Oak avenue, for instance, the difference in elevation between the two grades would be 3.0 feet, this point being approximately 1,000 feet from the outlet.

2d AREA BETWEEN WYLLYS ST. AND WARWARME AVE.

For the district east of Wethersfield avenue lying between Wyllys street and Warwarme avenue, it will be necessary to sewer only the northerly half, as the remainder is park land, and the run-off can probably be taken through the dyke as at present. The northerly half contains about 100 acres. The upper 25 acres are on a slope of 45 feet per 1,000 feet, and will shed 42 cubic feet per second. The middle 55 acres have practically no slope, but when built upon could probably be figured at one foot per 1,000, shedding 36 cubic feet per second. The remaining 20 acres are on the westerly slope of the dyke at about 10 feet per 1,000, shedding 26 cubic feet per second. The aggregate reaching the outlet, therefore, is 104 cubic feet per second, requiring a circular sewer 5 feet 4 inches diameter at 0.1 per cent. grade.

The ground plan of the development of this section will determine the location of the main sewer, but it would seem best to build it in either Masseek street or Weehassat street, the present outlet being through the latter. The 5 feet 4 inches diameter should extend as far as Huyshope avenue where it can reduce to 4 feet 9 inches to extend half way to the foot of the steep slope, where it should again reduce to 4 feet 3 inches for the remainder of this distance, then reduce to 24

inches at 4.5 per cent. and gradually taper to 10 inches near Wethersfield avenue.

If the new trunk sewer should be built in Huyshope avenue the above described sewer could connect with it. It seems to me that the reconstruction of several of the local sewers in the Colt Meadow district, at the earliest possible date, is especially urgent, and I do not see how this work can possibly be delayed until the completion of the Colt Meadow interceptor. I believe the city should proceed with the lay-out of the system north of Wyllys street, as herein outlined, at once, and that the construction work should be completed in 1910 at the latest. If carried out now, the only part of the system which might later be abandoned would be the new sewer in Taylor street.

FUTURE DISPOSAL OF SEWAGE FROM THE FRANKLIN AVENUE DISTRICT

A discussion of the east side flood protection would not be complete without a brief statement as to the future disposal of sewage from the Franklin avenue district.

This district is as completely isolated from the other drainage areas of the City of Hartford, as though it were located in another town, and although it would be possible to collect and treat the sewage from it with that of the rest of the city, the cost would probably be prohibitive.

As a part of this drainage district is located in the Town of Wethersfield, and its outlet has always been through this town, it seems best to consider this area in conjunction with, and as a part of the drainage system of the Town of Wethersfield.

The main outlet of the Franklin avenue district, which was constructed in 1880, was formerly located a short distance north of the entrance to Wethersfield Cove, but in 1903 this outlet was extended southerly for several hundred feet, at the request of the Town of Wethersfield, and now discharges into the Connecticut River at a point much further out from

shore, where the water is deep and the current swift, so that for several years at least, I cannot see how this sewage can be offensive or create a nuisance. I believe that the Town of Wethersfield will need sewerage facilities before the City of Hartford will be compelled to abandon its present method of sewage disposal for the Franklin avenue district. However, it is well to consider the matter at this time in order to thoroughly understand, from a typographical standpoint, the relationship between the Franklin avenue drainage district, formerly known as the "Great Swamp," and the Town of Wethersfield.

Until 1722 that part of Hartford now served by the Franklin avenue sewer was drained by a brook which flowed through the Town of Wethersfield about where the Valley Railroad now runs, and emptied into the Connecticut River just above the Rocky Hill dépot.

On December 11, 1721, the selectmen of the Town of Wethersfield were instructed to "consider the advantages and disadvantages of turning the Brook by Dan'l Rose's cross the highway by Poke Hill into the Cove." On March 5, 1722, they reported "that according to all we could see suitable to judge upon we judge and conclude that ye advantages of turning said brook as aforesaid would be, whether to the town or the proprietors, 10 times so great as ye disadvantages would be, they were thereupon ordered to do it, at the expense of the town."

The new brook must have cut its way through the clay bank at Wethersfield avenue very rapidly, for on March 2, 1783, the town rescinded its former vote and instructed the selectmen "to turn sd. water course into its ancient channel and do what they judge fitting for a convenient and safe road." They must have made a report to the effect of "dam it we can't," for the "Folly," as the cut was thereafter called, continued to grow deeper and more dangerous in spite of votes, suits, acts of the General Assembly and committees ad libitum, until in 1801 a bridge was finally built at the present site at a cost of of $1,109.77.

The "Great Swamp" in Hartford, which was thus drained by Wethersfield, extended nearly to Morris street, and it is thus evident that the ancient and natural outlet for all of this territory is through the Town of Wethersfield. There is today a fall of 1 in 1,000 from the ancient level of the swamp at the "Folly" to "Egypt," the section of Wethersfield where Middletown avenue crosses the brook. It is perfectly feasible, therefore, to build a trunk sewer with a minimum amount of digging through this old valley. The right of way should be comparatively cheap. The grades are suitable and the ground is firm. It would be necessary to lift the sewage from the present level up to the new outlet, but I apprehend that pumps will be necessary no matter what is done, whenever the present outlet is abandoned, and the lift would not be excessive. Though I have not figured the comparative costs, I believe this to be the best location for an outlet sewer to drain the Town of Wethersfield, and it can easily be determined whether the cost to both city and town would not be less if co-operative action were taken, than if separate trunk sewers were built over any other routes. At present I believe it would. The section of Wethersfield naturally draining north through Franklin avenue is a part of this same ancient basin, and should logically be handled the same way,— by co-operation. Franklin avenue at the city line is so much lower than at Jordan Lane that it is impracticable to drain it any other way. A sewer could be carried east, just south of the city line, and discharge into Folly Brook, but it would be such a nuisance that a filter plant would have to be established near the city limit, or else the sewage taken into the Franklin avenue outlet.

A sewer will be necessary in the lower end of Franklin avenue at some time, to serve the present unsewered Hartford frontage, and this would be the natural and logical outlet for that portion of the Franklin avenue drainage area within the Town of Wethersfield. The land drainable through this outlet is a narow strip on each side of Franklin avenue, and

the new road which is practically its extension. The maximum number of feet of sewer which could be connected would be, in Franklin avenue 1,630; in Jordan Lane, to the east 650 — to the west 1,000; in the New Road its full length, 2,700; a total of 5,980 feet.

New streets may be opened at right angles to both the main roads, but their length would seldom exceed 1,000 feet, and in most cases be much less. Without having measured the area of the watershed I think it would be impossible to lay out more than 13,000 feet of new streets, and probably not one-third of that number will ever be built. North of Jordan Lane the streets would naturally develop parallel to Franklin avenue, and thus drain by different routes. But even estimating on the maximum development of this area, the discharge of sewage and ground water would not be sufficient to require a very large pipe at the city line.

I would certainly recommend that the City of Hartford allow all of the sewage and ground water from this area to drain by gravity to the city line at Franklin avenue.

The storm water question is a separate matter. Wethersfield ought to consider a sewer large enough to handle it, as there already is a 24-inch tile laid north from Jordan Lane for several hundred feet, and similar shallow storm water sewers can be provided whenever the district is built up enough to demand them. Hartford could permit an extension of these sewers to Folly Brook where they would discharge without damage.

IN CONCLUSION.

As the detailed study of the east side flooding problem has been extended over several years under the direction of different council committees, I wish, at this time, to commend in the highest terms the faithful and efficient services rendered by all of the men who have served upon the various committees connected with this work. They have given unsparingly of their time and energy, and have endeavored to

find the best possible solution of this difficult problem. I also wish to express my hearty appreciation of the services rendered by Mr. R. N. Clark, Mr. Henry Robinson Buck and Mr. Robert A. Cairns.

Respectfully submitted,

FREDERICK L. FORD,

City Engineer.

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APPENDIX

Plates indicating districts affected and data governing treatment of problem.

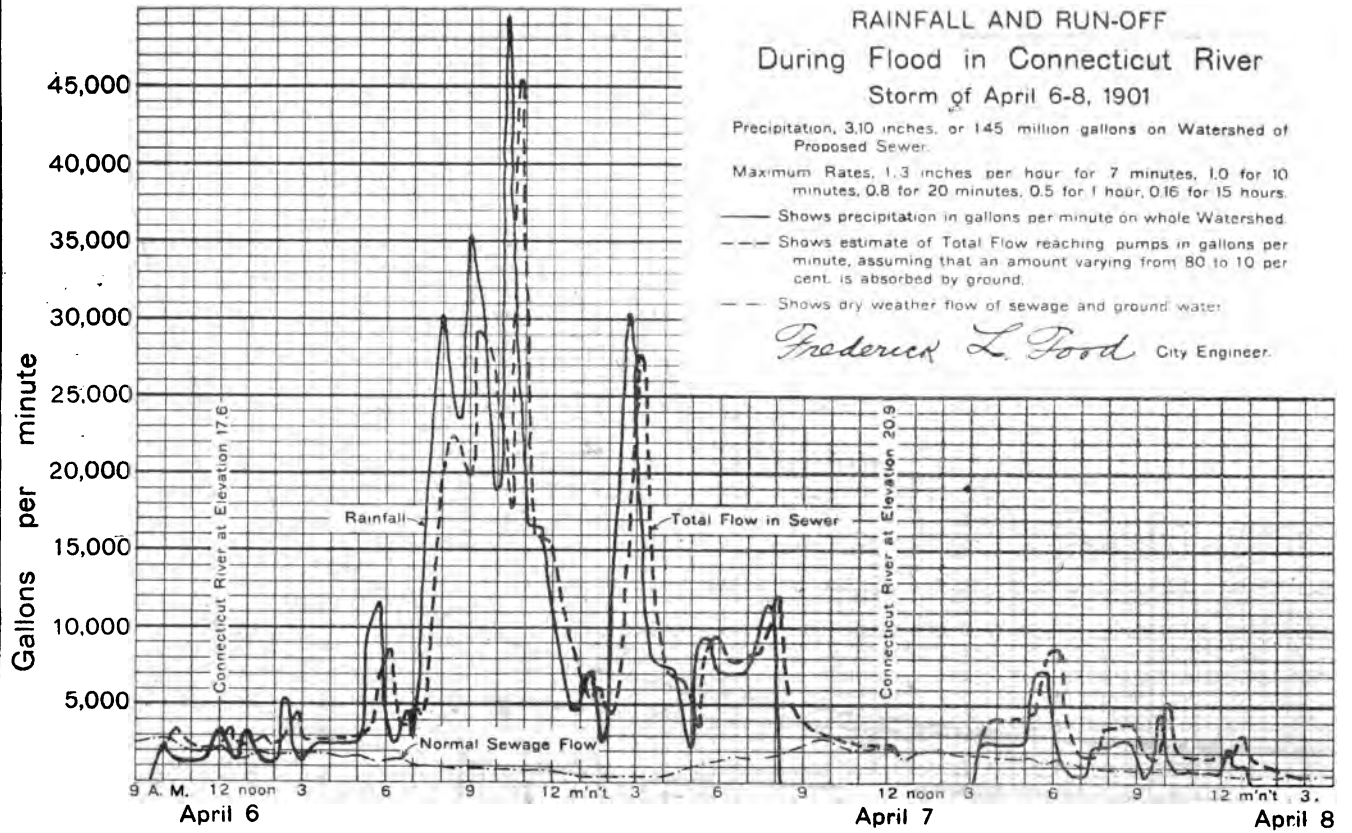
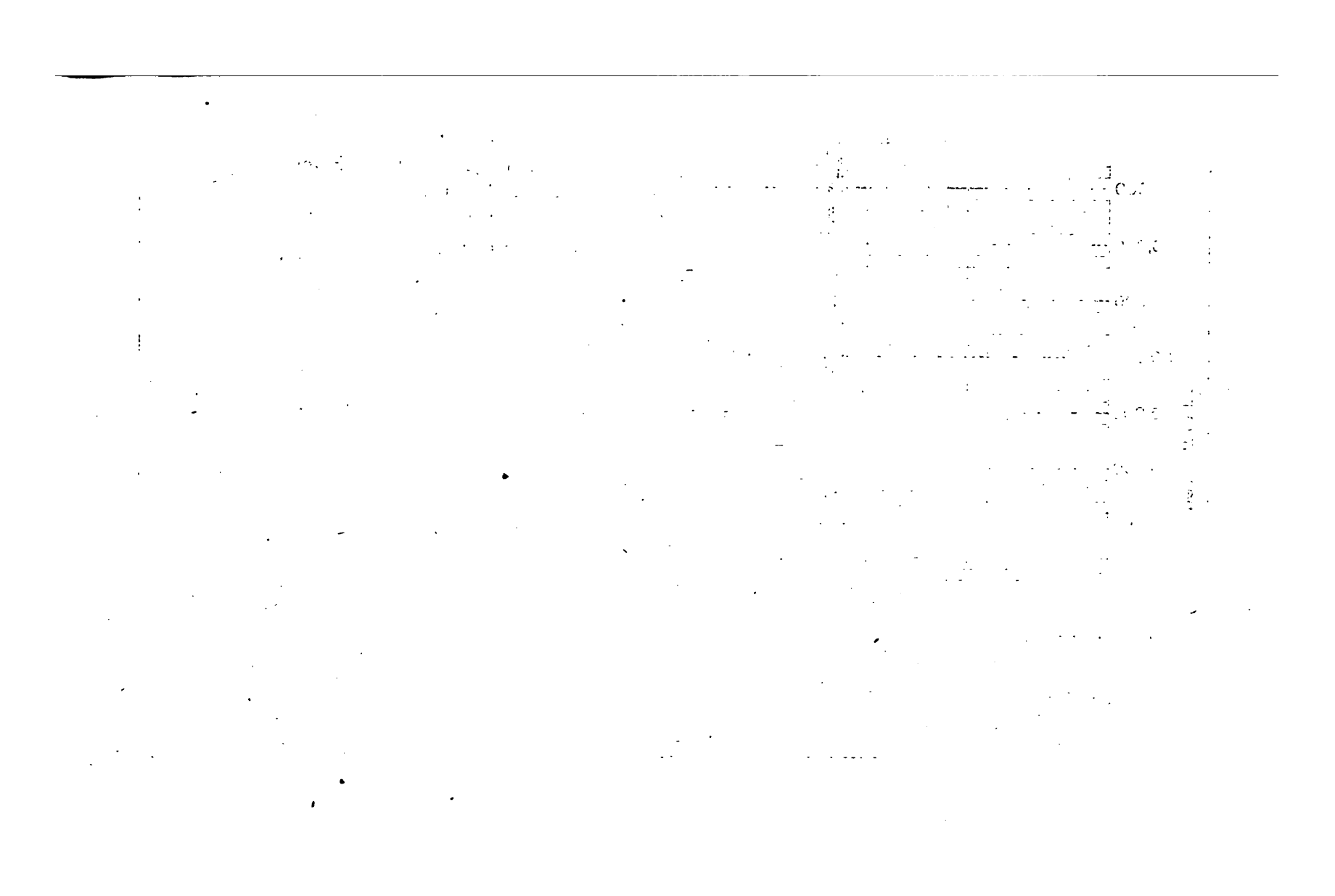

RAINFALL AND RUN-OFF
During Flood in Connecticut River
Storm of April 6-8, 1901
Precipitation, 3.10 inches, or 145 million gallons on Watershed of Proposed Sewer.
Maximum Rates, 1.3 inches per hour for 7 minutes, 1.0 for 10 minutes, 0.8 for 20 minutes, 0.5 for 1 hour, 0.16 for 15 hours.
—— Shows precipitation in gallons per minute on whole Watershed.
– – – Shows estimate of Total Flow reaching pumps in gallons per minute, assuming that an amount varying from 80 to 10 per cent. is absorbed by ground.
– – Shows dry weather flow of sewage and ground water.
Frederick L. Flood City Engineer.
Gallons per minute
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
Connecticut River at Elevation 17.6
Rainfall
Total Flow in Sewer
Connecticut River at Elevation 20.9
Normal Sewage Flow
9 A. M. 12 noon 3 6 9 12 m'n't 3 6 9 12 noon 3 6 9 12 m'n't 3.
April 6
April 7
April 8

PLATE 1.



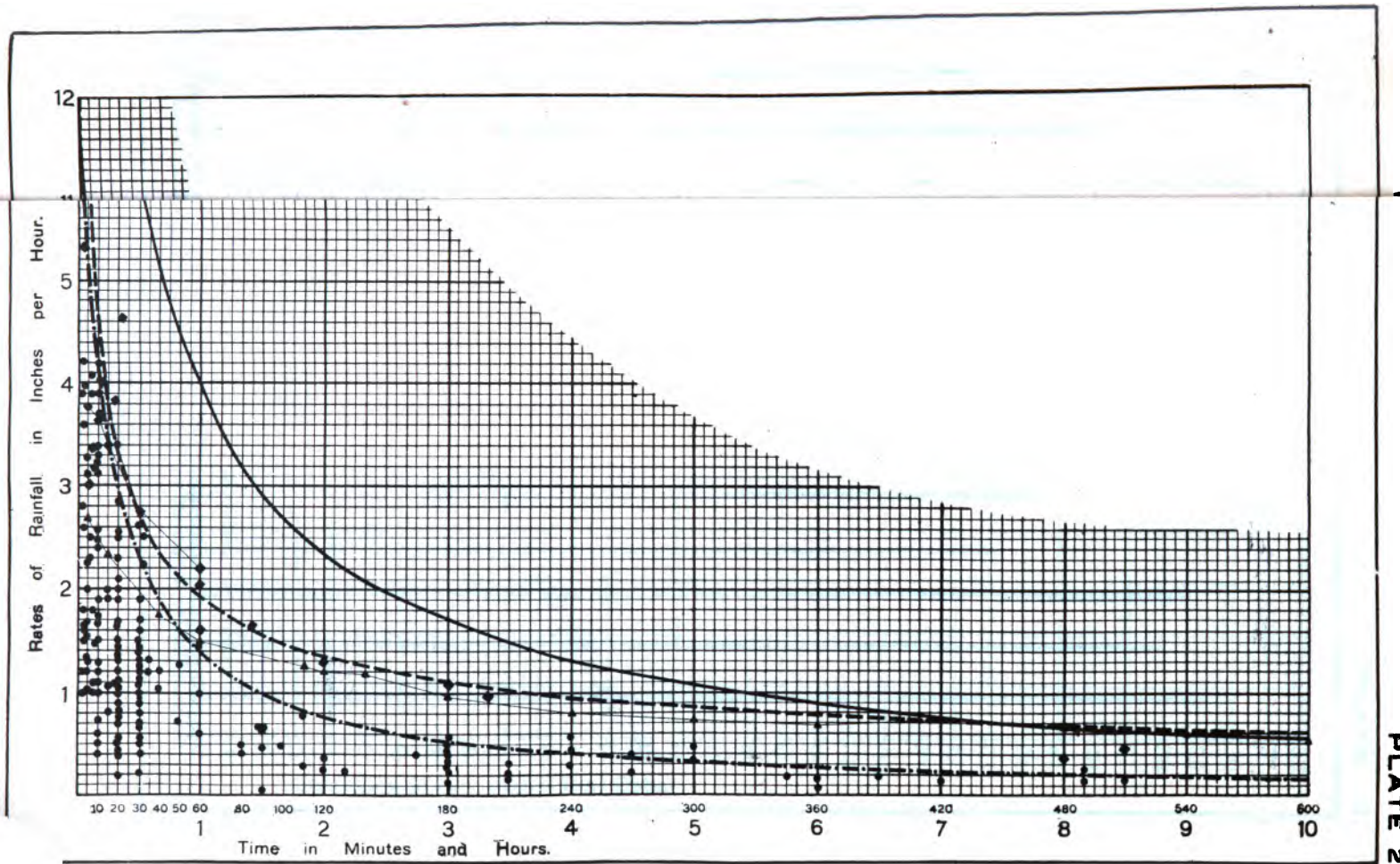

Rates of Rainfall in Inches per Hour.
12
5
4
3
2
1
10 20 30 40 50 60 80 100 120 180 240 300 360 420 480 540 600
1 2 3 4 5 6 7 8 9 10
Time in Minutes and Hours.

PLATE 2.

PLATE 2.

DIAGRAM SHOWING RELATION
RATES AND DURATION OF RAINFALL
10
9
8
7
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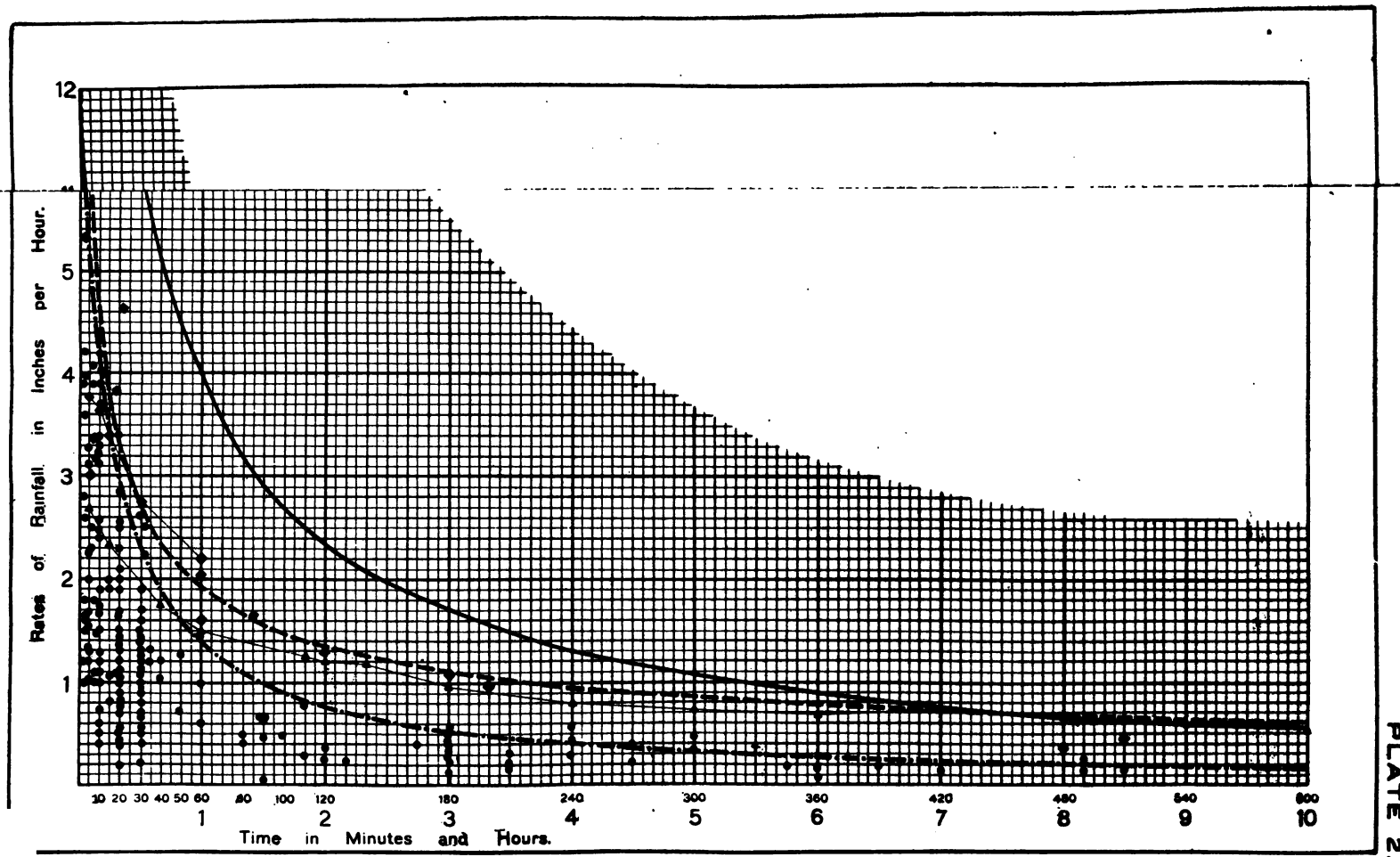
5
4
3


Rates of Rainfall in Inches per Hour.
12
5
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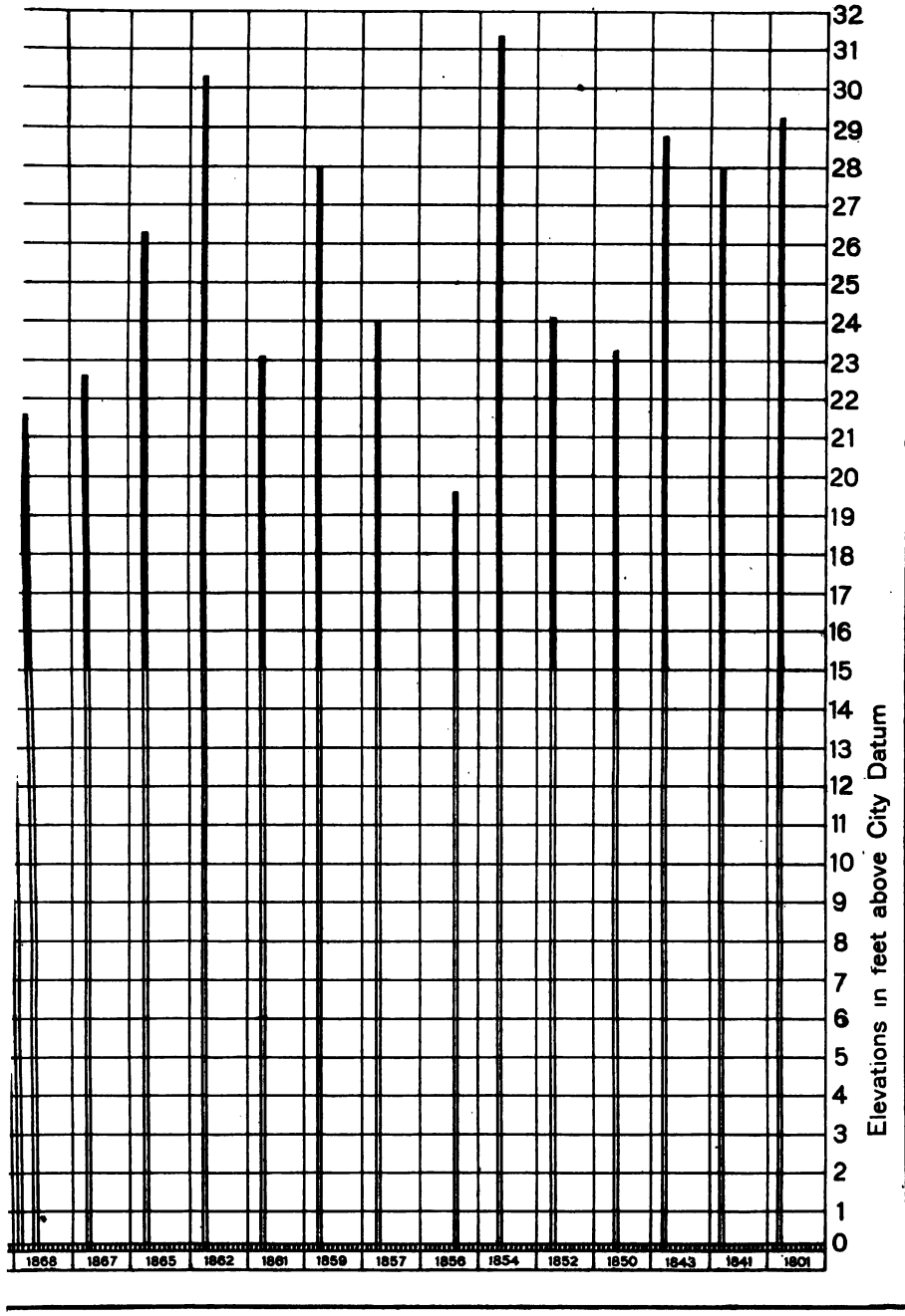
1 2 3 4 5 6 7 8 9 10
Time in Minutes and Hours.

PLATE 2.

PLATE 2.

PLATE 3.


32
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17
16
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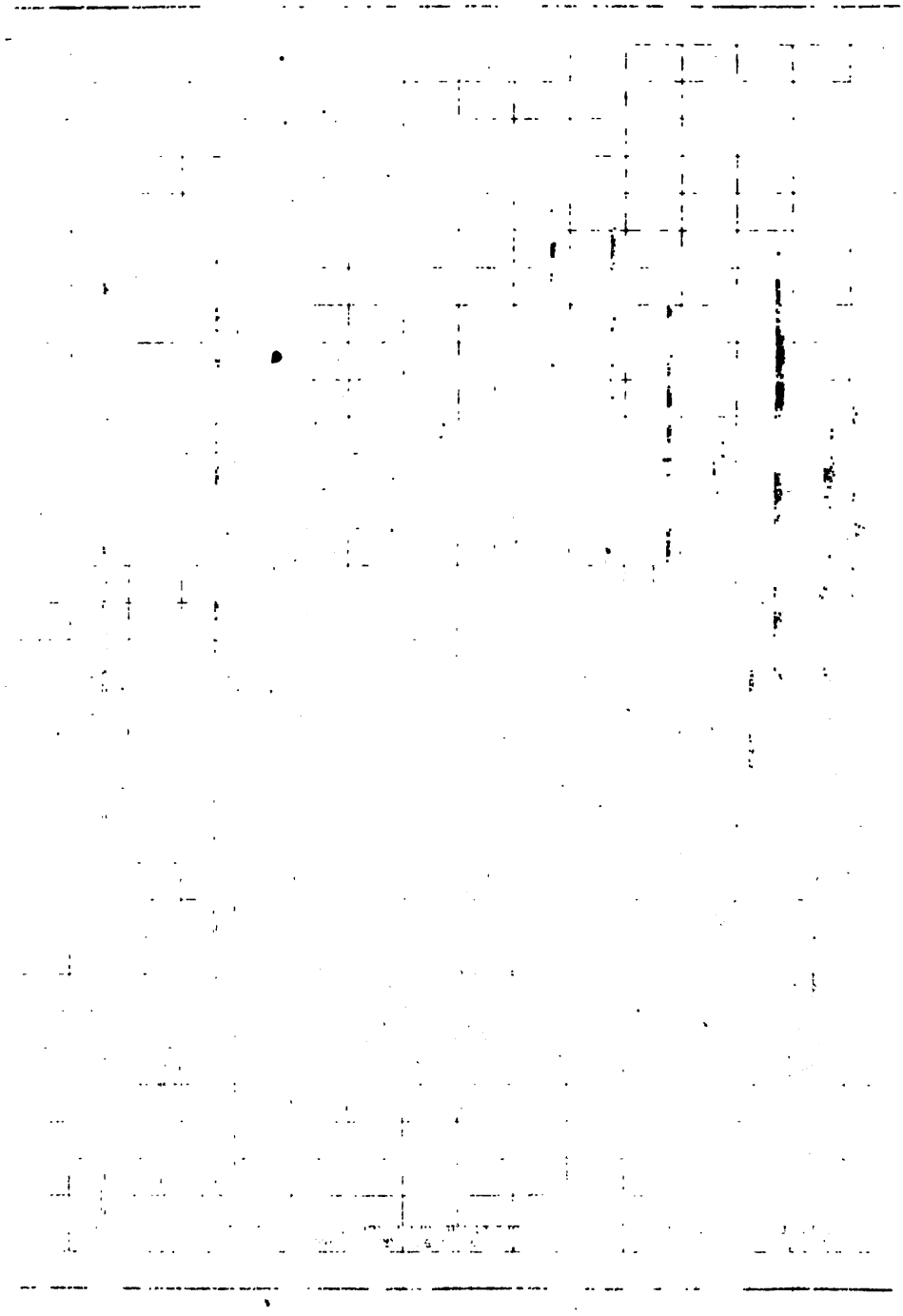
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Elevations in feet above City Datum
1868
1867
1865
1862
1861
1859
1857
1856
1854
1852
1850
1843
1841
1801



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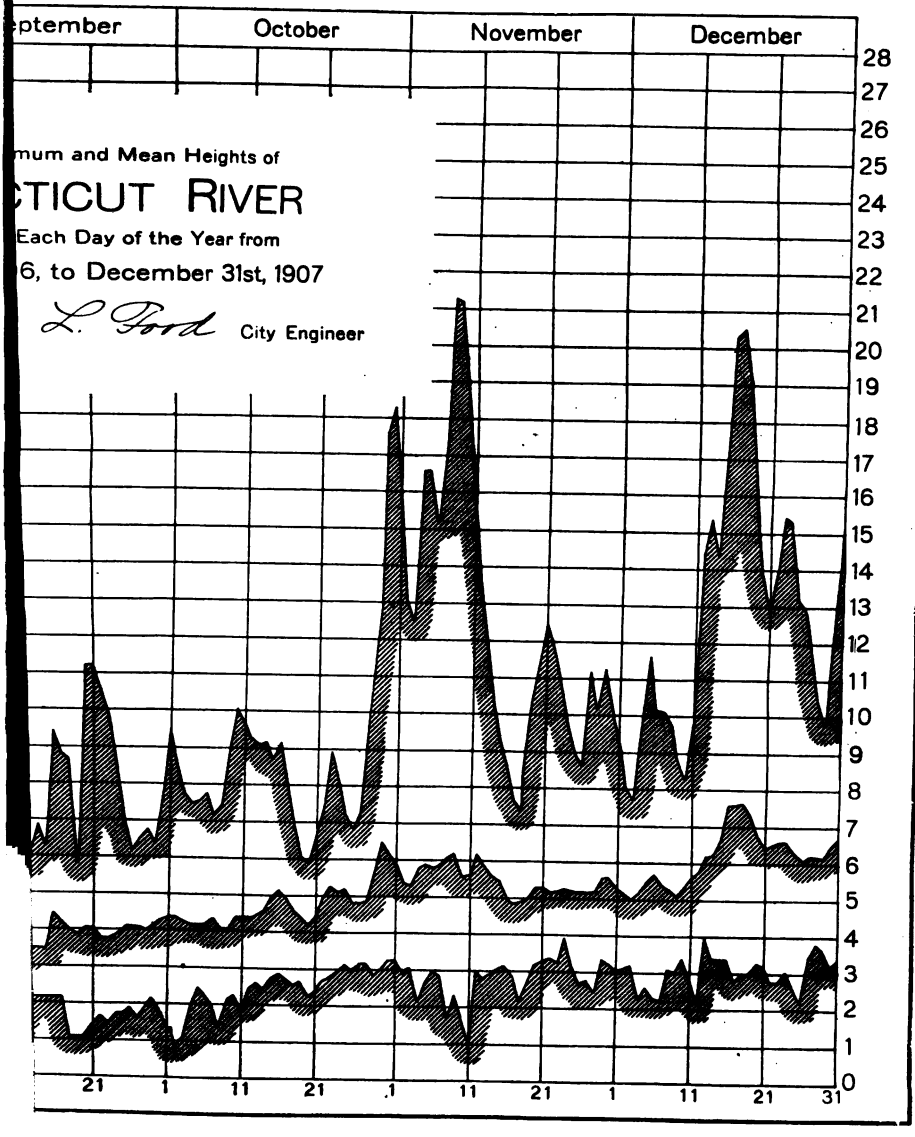
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L. Ford City Engineer
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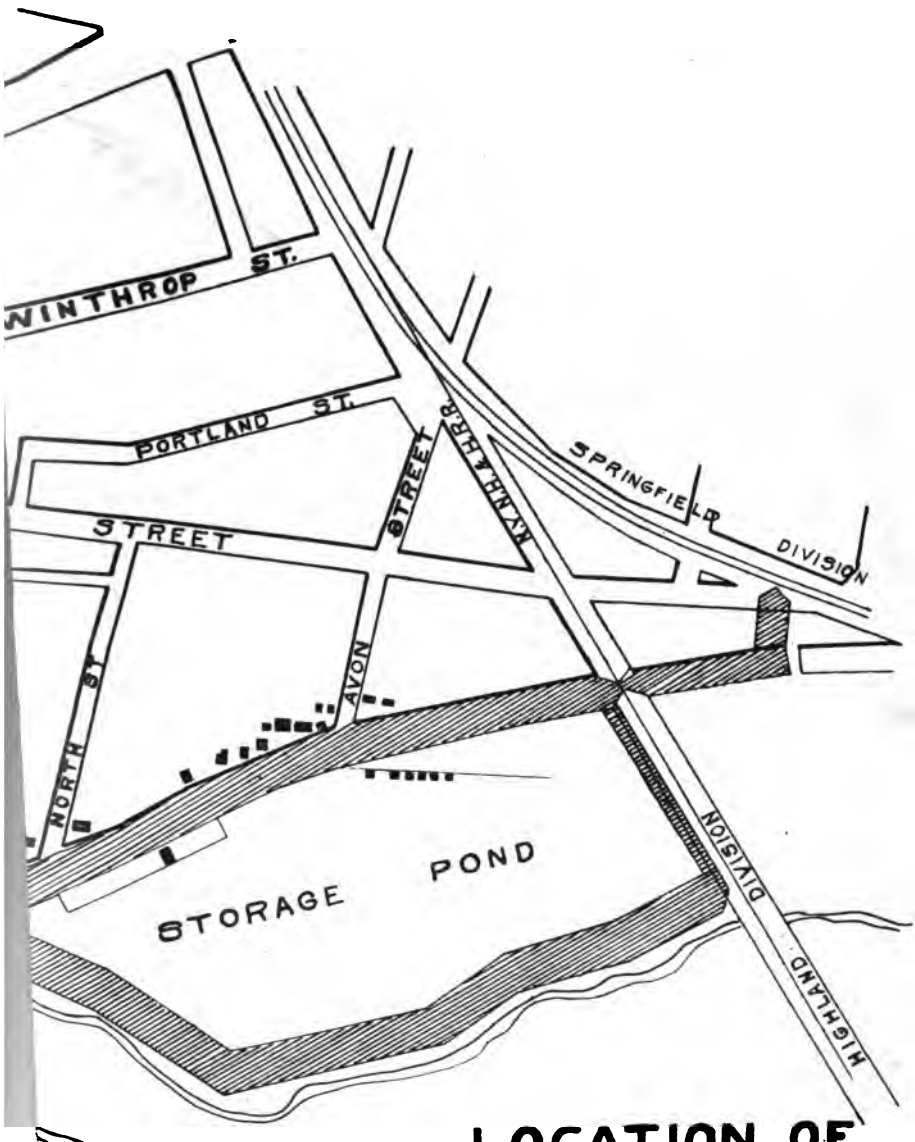
PLATE 6.

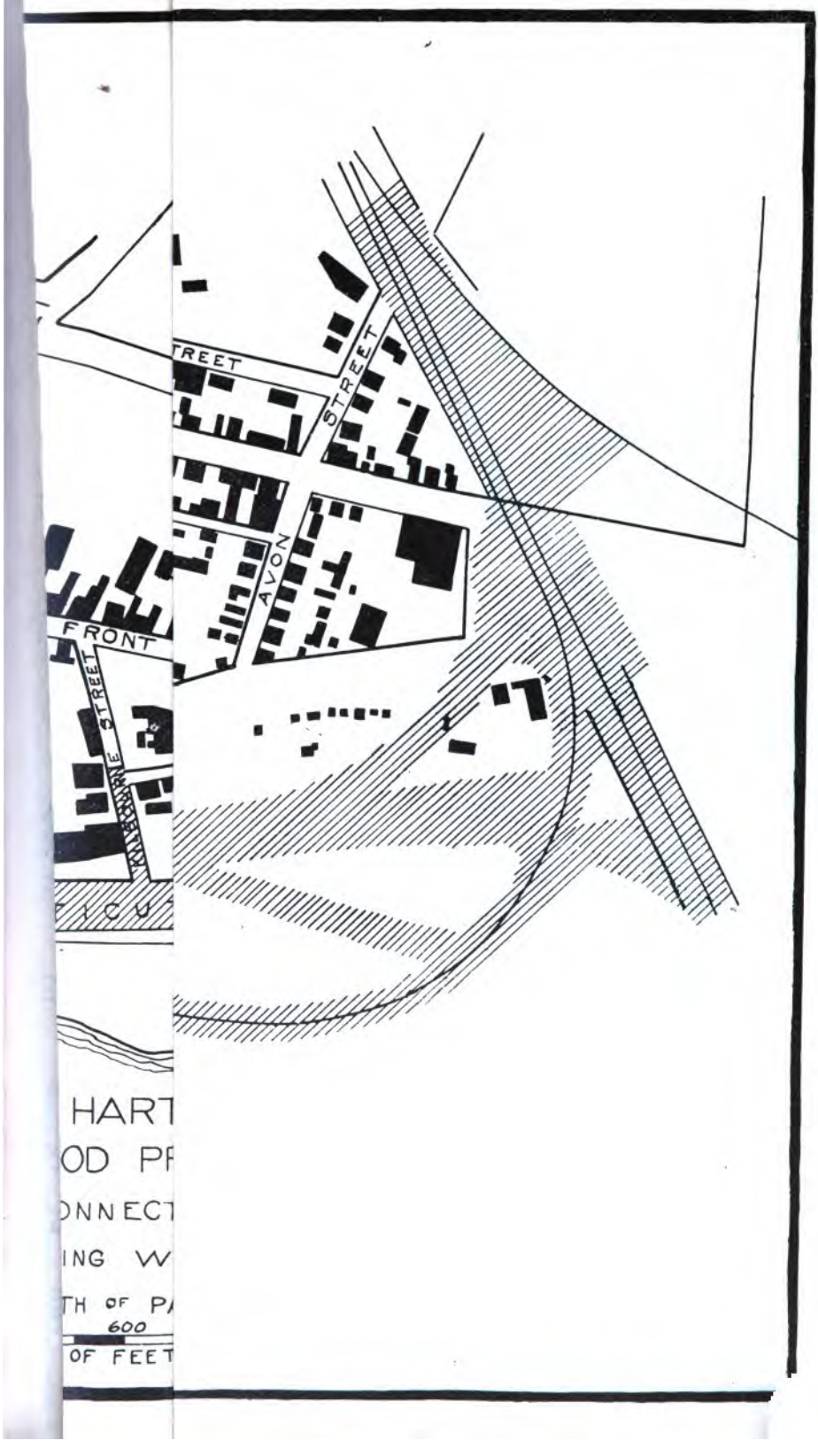


LOCATION OF DYKE AS PROPOSED BY JAMES LAURIE

SCALE

1866 FEET

PLATE 8.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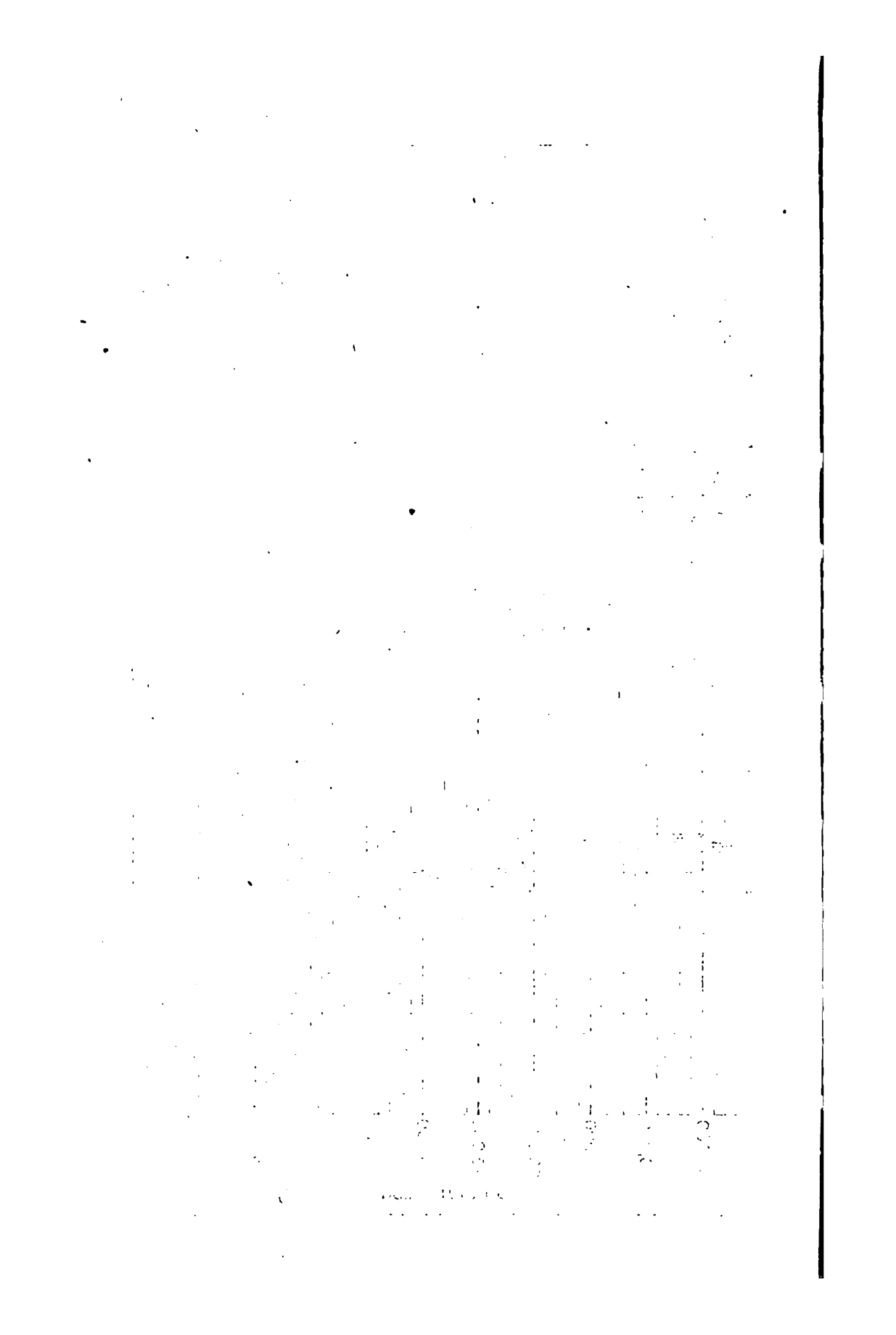

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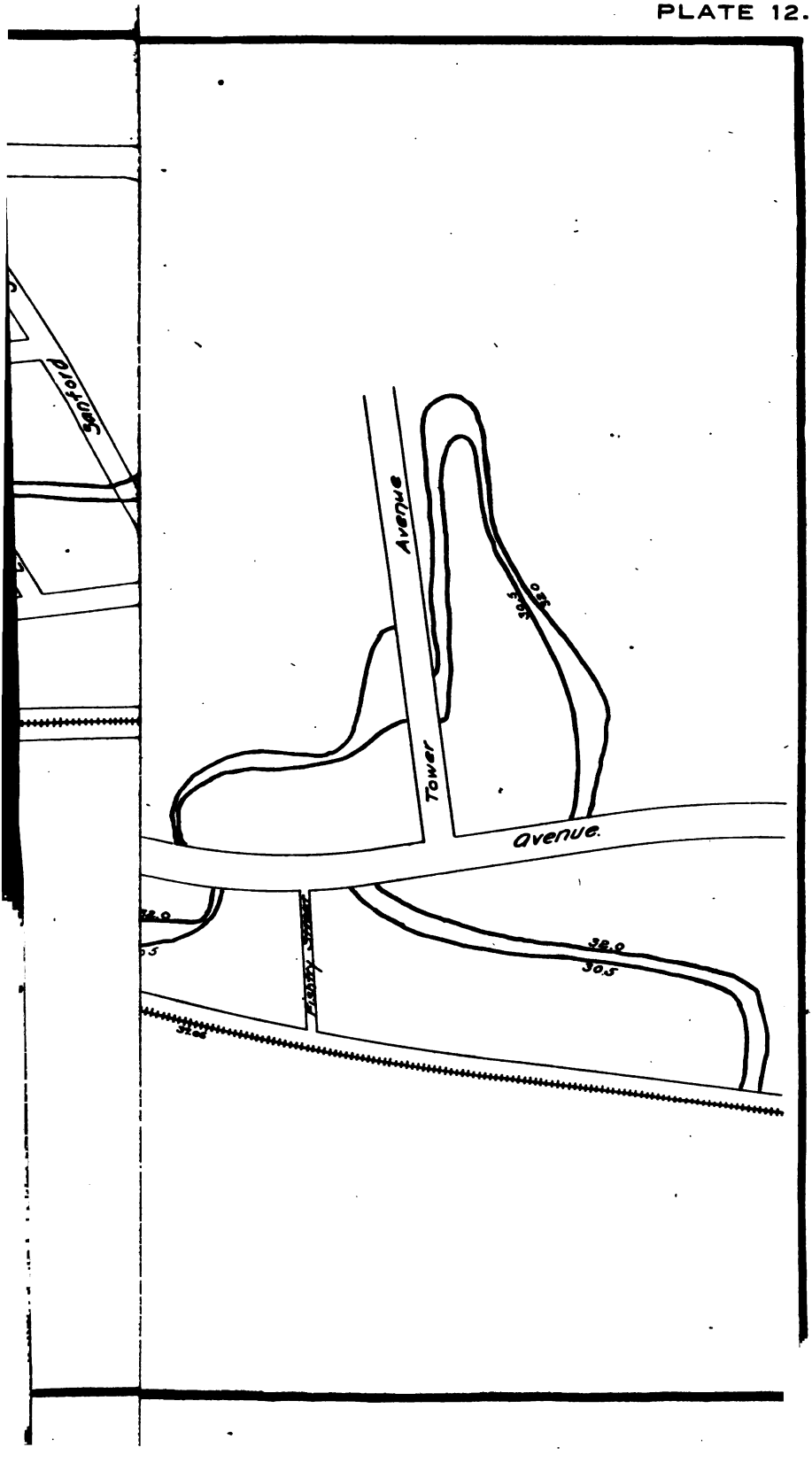

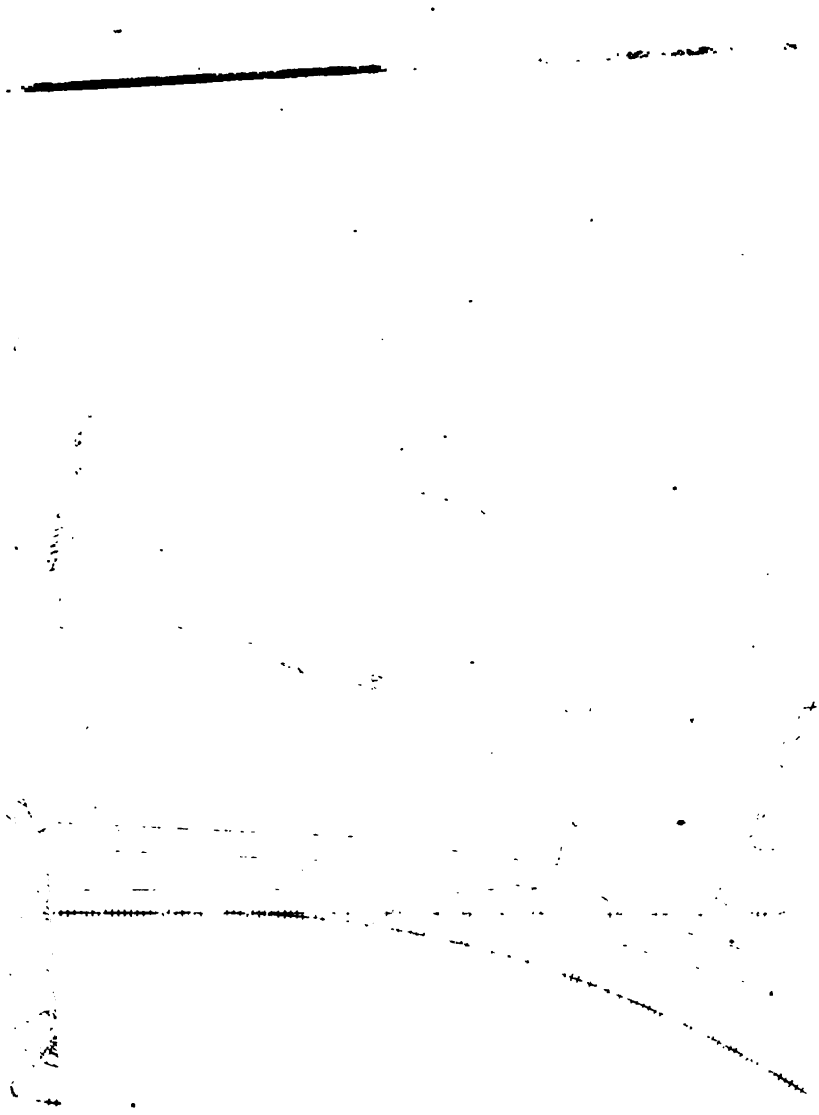

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